ELEMENTARY SCIENCE LESSONS

STANDARD II.

BY THE SAME AUTHOR.

A COURSE OF SIMPLE OBJECT LESSONS FOR INFANTS. Two Series. Fcp. 8vo. 8d. each.

ELEMENTARY SCIENCE LESSONS, being a Systematic Course of Practical Object Lessons. Illustrated by Simple Experiments. (Four Parts), Standard I. Fcp. 8vo. 1s. 6d.

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ELEMENTARY SCIENCE LESSONS

BEING A SYSTEMATIC COURSE OF

PRACTICAL OBJECT LESSONS

BY

W. HEWITT, B.Sc.

STANDARD II.

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PREFACE

THE present volume consists essentially of a systematic course of Practical Object Lessons, designed and arranged specially for the purpose of developing and training the minds of young children. As such it might stand by itself, or be combined with any other course of lessons, being general and fundamental in its character.

It forms the second year's course of a system of Elementary Science Lessons (such as those contemplated by the Revised New Code), which will carry the children step by step from the preliminary and general training of the lower standards to the more specialised science lessons for older scholars.

The present series is drawn up on similar lines to the first series, but is somewhat more advanced in character; and although it might readily be taken as an independent course of object lessons, it would be much more valuable as an educational training if preceded by the simpler lessons contained in the first year's course (Standard I.).

The author can speak from a long experience of

science teaching in elementary schools as to the educational value of practical object lessons, with simple experimental illustrations of the character of those sketched out in the following pages, in cultivating the intelligence of the children.

The scheme, of which the present course forms a part, was drawn up at the request of the Liverpool School Board to meet a long-felt necessity for a continuous and connected system of practical object lessons running throughout the whole of the elementary school course and developing into the more specific experimental science teaching of the higher standards.

W. H.

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INTRODUCTION

SUGGESTIONS TO THE TEACHER

THE general principles upon which this course of Practical Object Lessons is based were explained in the Introduction to the series for Standard I.; it is therefore only necessary here to state that the lessons contained in this second series are drawn up on exactly similar lines. They are, however, a little more advanced in their general character: dealing with more specialised subjects, which require closer and more careful observation, and which call for somewhat more developed powers of reasoning and generalisation.

It will be observed that the lessons are for the most part arranged in groups, each of which seeks to develop some general idea—either the main properties of a typical substance or the characters of a special class of bodies. The last lesson in each of such groups is so arranged as to serve for the recapitulation of the principal facts observed in the preceding lessons, and at the same time to show their connection with each other.

Although the paragraph at the head of the notes in each lesson is intended to indicate the idea of the lesson and its relation to those which have preceded it, it may be well in this place to explain briefly the general arrangement of the series, so that the teacher may be led to view

the series as a whole, and appreciate the relations between its various parts. The first few lessons treat of several familiar substances, which are studied not so much with reference to their special properties, as to illustrate the facts which lead us to associate together certain substances under the heads of solids, liquids, and gases respectively—the phenomena of melting, solution, and evaporation being briefly dealt with in this connection. The next group of lessons deals with some of the important characters of iron and steel; the facts being ascertained by considering the special uses of several familiar objects constructed of those substances. It is then shown in simple lessons on lead and silver that other substances possess certain characters in common with iron; and this observation leads to a general lesson on the class of substances known as metals. The brightness of clean metallic surfaces next suggests certain lessons treating of the sources and the reflection of light. The examination of sunlight, and the effects produced when the light is passed through a prism, introduces a group of lessons dealing with colour—a subject which does not receive sufficient attention in our schools, except, perhaps, in the infant classes. The remaining lessons do not fall quite so naturally into one or more groups; but the general ideas running through most of them are that motion is of various kinds: that the form of the body has a very important influence on the nature of the motion: and that some cause (force) is necessary to the production of motion in a body.

From what has just been said as to the arrangement of the series, the importance of taking the various lessons in the order here arranged will readily be understood. They might, as a general rule, be taken at the rate of one per week; and each lesson will be found sufficient to occupy from thirty to forty minutes.

As the illustrations and experiments are absolutely essential if the full educational value of the lessons is to be realised, it is necessary that the teacher should carefully study the notes and prepare the required apparatus before attempting to give the lesson. The apparatus suggested is of the simplest possible character; but experience shows that such an arrangement has the great advantage of not distracting the attention of the children from the principle to be illustrated in the way that unfamiliar and novel objects are very apt to do.

It would be of advantage in many cases, where it is possible, to follow up the object lesson by practical exercises on the part of the children themselves, in which they should be led to apply the principles illustrated in the lesson. This would be especially valuable in connection with the lessons on colour; where the children could be set to select and arrange specimens of various coloured wools, to form patterns in coloured paper or cardboard, or to colour with crayons drawings and designs of their own construction.

In connection with the titles of the lessons it should perhaps be pointed out that there is no intention to imply that the object which gives the title to the lesson is to be submitted to anything like a full and complete examination (as is sometimes attempted in ordinary object lessons), but only so far as is necessary to illustrate the special principles which the lesson is designed to bring out. Thus, for example, in the lesson on glycerine, it is not intended that the source, nature, composition, and uses of the substance should be studied; but it is considered as something which, though certainly not water, yet has various properties in common with water, which lead us to class the two substances together under the name of liquids.

The teacher may be again reminded that the children are to be led to ascertain the various facts and principles for themselves, as the result of their own observation and reflection; the information contained in the notes of the lessons is, as far as possible, to be drawn from the children rather than imparted to them. The more fully the teacher realises this principle of instruction, the more effectually will the lessons accomplish their primary purpose—that of developing and training the minds of the children.

LESSON I.

A GLASS OF WATER.

OBJECTS REQUIRED *Glass, nearly full of water; lead pencil (or small pointer); several marbles (or small stones); cork; wooden ball or inch cube.*

ANALYSIS OF LESSON.

Recognition of substance in glass; its uses.

Observation of various properties of liquids, viz.:

(1) Surface is straight line—level.

Ex.—*Hold pointer parallel to surface of liquid.*
Draw outline diagram of vessel showing

Ex. *Hold pointer parallel to surface in inclined vessel.*
Draw outline diagram of water in same.

(3) Substance very easily moved.

Ex.—*Touch surface with pencil; blow on it.*
Move the glass sideways.

(4) Stones and similar bodies sink through it.

Ex.—*Support marble or stone on hand, table, &c.*
Place marble in water—then several.

Explain movement of water to afford passage for marble, and note rise of level.

(5) Light bodies are supported—float.

Ex.—*Place cork on water, then wooden cube, noting displacement of some liquid.*

(6) Fills part of vessel—no spaces amongst liquid.

Ex.—*Put in pencil or finger and remove it.*
Make drawing showing level surface over marbles at bottom.

Recapitulate facts observed.

NOTES.

Subject of Lesson.—This is the first of several lessons intended to call attention to those characters of bodies which lead us to classify them as solids, liquids, and gases. In this lesson the children are led to observe certain characters of water which they will afterwards find to be more or less true of a number of substances; and they will thus see the reason for grouping all such substances together under the general name of *liquids*.

Commence with a few introductory and general observations about water—e.g. let the children state what substance they think it is in the glass, and what reasons they have for thinking so; the uses of water to us, &c.

Then say that there are a number of different facts they might learn about the substance, even though they knew nothing as to where it came from or what it was. Lead them by questioning, or by setting them to perform the simple experiments, to observe and describe the following facts:—

(1) The top (or surface) of the substance is plainly seen, and is a straight line extending in a definite direction.

Let a child hold the tumbler on a level with his eye, point out with his finger the line referred to, and hold a pointer or pencil in a similar direction. Make a simple outline diagram of the vessel on the blackboard, and draw a line to represent the surface of the liquid—which may be spoken of as being 'level.'

(2) The surface remains extended in the same direction as before (i.e. level) however the vessel may be inclined.

Incline the vessel to one side, let a child hold the

pointer to indicate the direction of the surface, and again draw an outline diagram on the board.

(3) The substance is very easily moved.

Show this by gently striking the glass with a pencil, touching the water lightly with the pencil, blowing gently on it, and lifting and moving the glass.

(4) Stones and similar bodies will not rest on the water as they will on the table or the hand.

Lay a small marble or stone on the hand, and describe the hand as holding it up; lay it also on the table. Then put the marble on the water, and lead the children to describe the water as moving aside so easily as to let the marble sink or fall through the liquid till it comes to something which can support it.

Put in several more marbles or stones, and let the children note the rise of the water, and explain it—viz. that each marble readily pushes aside into another part of the vessel the water in its way.

(5) Some bodies, however, are supported by water.

Place a cork on the water and let the children describe it as floating, and name other substances which will float on water. Show them a small wooden ball or inch cube floating. Lead them to observe that even in this case some water is pushed aside—*displaced*—and the bodies sink a little way into the liquid.

(6) The water lies close up to the sides of the vessel, filling up that portion in which it lies, and leaving no visible spaces.

Put in the pencil or finger and observe that when it is removed the water runs back into its place; and also note how it closes up again after the marble has dropped through, leaving no sign of any hole or break. Make a drawing on the board showing the surface of the water in the vessel as a straight continuous line with the

marble lying at the bottom. There is thus no indication on the surface of any objects below.

Revise the lesson by letting the children describe, as much as possible in their own words, and in complete sentences, the facts which have been observed.

[*Note.*—The facts to be observed in this and the following lessons must not be first stated to the children and then illustrated; but, as a rule, the illustration should first be shown, and then the children led to describe it, and so to state the principle which the experiment was designed to illustrate.]

LESSON II.

A GLASS OF WATER—*(continued)*.

OBJECTS REQUIRED *Glass of water; pencil (or glass rod); plate; flat-sided bottle; slate; blotting paper; marble; wooden cube. (A glass funnel for use in pouring water into the bottle would be convenient.)*

ANALYSIS OF LESSON.

Recapitulation of preceding lesson.

Observation of other facts about water, viz.:

(1) Sticks to ("wets") most bodies; parts easily broken from mass and easily joined again.

Ex. *Dip finger and pencil in water.*
Let drops fall again into glass.

(2) Can be easily poured out.

Ex.—*Pour water on to plate and into flat sided bottle; note level surface.*

(3) Spreads out till stopped by sides of vessel.

Ex. *Point out raised sides of plate.*
Children place hands as if holding water.

(4) Runs easily down sloping surface—gutters, streams, &c.

Ex. *Let drops fall on inclined slate, children first stating expected result.*

(5) Readily penetrates (soaks into) many bodies—sand, calico, duster, &c.

Ex.—*Dip blotting paper and handkerchief in water.*
Drops falling on blotting paper and soaking through.

Recapitulate facts observed in this and preceding lesson.

Other substances having similar properties—paraffin oil, &c.

NOTES.

Subject of Lesson.—The glass of water is further examined in this lesson in order to complete the enumeration of the characters which it possesses as a type of liquids generally.

Begin the lesson by letting the children state, as far as possible without assistance, the facts observed about the water in the previous lesson, and let them illustrate their statements by such simple 'experiments as were shown on that occasion.

Then continue the study of the general characters of water by leading the children to observe—

(1) The water sticks to most things and is said to 'wet' them, and often hangs from them in 'drops.'

Dip the finger and a pencil in the water; note that *something adheres to them which may be wiped off*, and that *it hangs from the end in the form of a drop.* Let drops fall into the water again, and note that they mix at once with the rest of the water and there is no sign of their having been broken off. Thus, parts of the water may easily be separated from the rest and readily joined together again.

(2) It can not only be moved about easily in the vessel, but also poured from one vessel into another.

Pour some water on to the plate, and some more into a flat-sided bottle. (Hold the bottle over the plate while pouring in the water, and notice again the straight and level line of surface.)

(3) The water on the plate and in the bottle spreads itself out until it is stopped by the upright sides.

Let a child point out the turned-up sides of the plate, and let several children hold their hands as they would

do if they wished to take up some water in them (as when washing themselves).

(4) It runs readily along a sloping surface, forming a little stream.

Ask some child to hold a slate in an inclined position on the table, and let the others state in what direction they would expect the water to run. Then let a few drops of water fall on the slate, and notice the little stream trickling downwards.

Remind them of the water running down the streets when it rains, and also in brooks and rivers.

(5) It readily soaks into many bodies.

Dip some blotting paper in the water, and let the children describe what takes place; ask them to name other substances into which water would soak in the same way—e.g. a handkerchief (illustrate this), duster, sand, &c. Let a drop of water fall on the blotting paper, and note how it soaks through to the other side.

Then, in conclusion, enumerate the various facts learnt in this and the previous lesson about water. Let the children say whether the same statements could be made of any other substances, and give the names of such—e.g. vinegar, paraffin oil, &c.

LESSON III.

GLYCERINE.

OBJECTS REQUIRED—*Glycerine in bottle (only partly filled and with rather wide neck); glass rod (or clean pencil); glass of water; sheet of glass (or slate).*

ANALYSIS OF LESSON.

Enumerate facts observed about water, and test whether true of present substance.

Ex. *Note level surface; incline bottle; draw diagram.*
Shake substance in bottle; displace with glass rod.
Let rod sink through it; remove rod and note filling up of space.
Note substance sticking to rod; let drops fall in bottle again.
Let drops fall on inclined glass sheet.

Reasons for thinking it is not water:—

Ex. *Shake bottle, and incline it; note slow movement.*
Dip rod in substance and note greater quantity adhering.
Show string of substance falling from rod into bottle.
Taste drop from rod.
Compare with water rubbed between fingers.

Name of substance.

Name other substances forming drops, having level surface, &c.

Characters common to liquids.

Names of liquids; **agreement with facts stated.**

NOTES.

Subject of Lesson.—Another substance—glycerine—is examined, and found to behave like water in many respects, and yet is proved, by taste and by other means, not to be water. Water, glycerine, and other bodies which behave in a similar way are grouped together under the general name of *liquids*.

Let the children again state some of the facts previously observed about water, and test the glycerine (without, however, mentioning its name) to ascertain whether the statements would also apply to it:—

(1) Note the straight, level (horizontal) surface; and the same also when the bottle is inclined.

(2) Note how easily it is moved by the glass rod (or pencil).

(3) Let the rod sink through it, and note how the substance fills up the space when the rod is removed.

(4) Lift out the rod, and note that the substance sticks to it and forms a drop. Let the drop fall into the liquid in the bottle, and note how all joins together again and settles down to form a level surface.

(5) Let a drop or two fall on an inclined sheet of glass (or a slate), and observe it flowing down.

In all these respects it is very similar to water, but is it water? Let the children answer this question, and give some reasons for their answer.

Lead them to observe and describe the following differences, some of which they probably will have noticed in the course of the previous experiments; all, however, should be again specially illustrated:—

(1) It moves much more slowly in the bottle, and is not so easily shaken about or poured out.

(2) It sticks more to the sides of the bottle and the rod.

(3) It forms a string as it falls off.

(4) It has a sweet taste. Let some child taste a drop from the end of the glass rod.

(5) It feels different from water when rubbed between the finger and thumb. Let several children touch the rod after being dipped in the glycerine, and then do the same with water, and note the difference.

The substance, therefore, is not water; perhaps some child can state what it is.

Let the children name some other substances which would form drops, have level surface, &c. Explain that water, glycerine, and all other substances which form drops, spread out to the sides of bottles and stand with a level surface, move even when just touched, &c., are called *liquids*. Let them name a number of liquids, and question them as to their reasons for saying that particular substances are entitled to be called liquids.

LESSON IV.

ICE.

OBJECTS REQUIRED—*Block of ice on plate; salt; hammer and bradawl (or stout needle) to break off pieces of ice; glycerine in bottle; slate; knife. (Ice can usually be obtained from a fishmonger's shop.)*

ANALYSIS OF LESSON.

Recognition of substance (ice)—how?

Ex. *Let child touch the ice.*

Origin of ice; melting.

Ex.—*Break off small piece and hold in hand; note drops and diminution of size.*

Water and ice are same substance; common properties.

Ex.—*Sprinkle salt on ice and note solution.*

Ice is not a liquid—why?

(1) Pieces of ice lie alone and do not spread out.

Ex.—*Lay piece of ice on slate.*

(2) Surface of ice not always straight and level; pieces have definite shape.

Ex.—*Draw outline of piece on blackboard.*

(3) Pieces may be held between fingers.

Ex.—*Hold piece of ice between finger and thumb. Try to press finger or pencil into ice.*

(4) Can support weight of heavy body.

Ex.—*Lay stone or hammer on ice.*

(5) Hollow spaces may exist in mass.

Ex.—*Scoop hollow in piece with knife.*

Bodies having these properties called *solid* bodies; name.

NOTES.

Subject of Lesson.—Water under certain conditions changes into ice, which is really the same substance, having certain special properties in common with water; but it has not the characters previously observed of liquids. It is therefore not a liquid, but is called a *solid* body.

Let the children state what the substance (ice) is, and how they recognise it. Let them first say what they would expect to find if allowed to touch the ice, and then let some of them touch it, and state whether it is cold.

Ask them where and when ice is found, how it is formed, and what it is formed from. Water is said to turn into ice; will ice turn into water, and if so under what conditions?

Break off a piece of ice (which is easily done by means of a hammer and bradawl or strong needle), hold it in the hand, and note the drops of water falling from it and the ice becoming smaller. Speak of the ice as *melting*.

Lead them then to understand that ice and water are really the same substance, and let them enumerate several reasons for this statement. Remind them that water and ice are alike in many respects—e.g. both will quench thirst, put out fire, and not burn themselves. Let them describe what happens when salt is put in water; then sprinkle a little salt on the ice, and note that it dissolves and disappears.

Water and glycerine are called liquids; should ice be called a liquid? Let the children point out how the ice differs from the water and glycerine, and help them by question and experiment to note such facts as the following:—

(1) Pieces broken off the ice will lie by themselves on a flat slate or plate without spreading out, but the water formed from them by melting spreads over the slate.

(2) The top of the ice is not always a straight and level line, and the shape of a piece remains the same, however it is turned about.

(3) A piece of ice may be held in the fingers, and the finger cannot be pushed into it.

(4) A heavy body, such as a stone or the hammer, may be laid on the ice, and it will support the body.

(5) A hollow may be scooped out in the ice with a knife, and the ice round about does not spread out to fill up the hollow space.

In all these respects ice is very different from water, glycerine, and other liquids, and must not be called a liquid. Let the children name other bodies which may be broken into lumps, which will lie by themselves, may be held in the fingers, will support stones, &c., and say that these bodies are called *solid* bodies. Ice is a solid body, it is water which has become hard and solid.

LESSON V.

WAX.

OBJECTS REQUIRED—*Piece of wax (white paraffin wax—a piece cut from a wax candle would do); book; knife; slate; small piece of thin glass (or tin) to melt wax on; candle in candlestick; matches.*

ANALYSIS OF LESSON.

Brief recapitulation of observed properties of ice, water, and glycerine.

Wax compared with ice and contrasted with water. Solid or liquid?

Ex.—*Lay wax in centre of slate or table; hold in fingers; rest book on it, &c.*

Is this solid substance ice? Why not?

(1) Not so clear and glass-like.

(2) Not so cold and hard.

Ex.—*Let child hold wax in hand and press between fingers.*

(3) Not break so readily.

Ex.—*Drop wax on table or floor; strike with knife or hammer.*

(4) May be cut into thin shavings.

Ex.—*Cut shavings of wax and lay on slate.*

(5) Does not melt so readily, but can be melted.

Ex.—*Lay shavings on glass (or tin sheet) and hold over candle flame till melted; incline glass; set aside to cool, then scrape off.*

(6) Will burn.

Ex.—*Show similar substance in burning candle.*

Name substance. Enumerate characters in which it agrees with ice.

NOTES.

Subject of Lesson.—Another solid body (wax) is examined to show that, while it resembles ice in those characters which lead us to call it a solid body, yet it has special characters of its own by which we learn that it is not ice but an altogether different substance. Special attention is also directed to the *melting* of the wax as an example of solids being changed into liquids by heat.

Question the children briefly on the preceding lessons; lead them to speak of water and glycerine as liquids, and of ice as a solid. Let them state the difference between ice and water which makes us call one a liquid and the other a solid.

Then point to the substance (wax) without naming it; let them say whether it is most like ice or water, and give some particulars in which it resembles ice and differs from water. Let the children illustrate their statements by simple experiments such as those shown in the last lesson with the ice—e.g. lay a piece of wax on a slate and note it lying there in a lump, hold it in the fingers, let the hammer or a book rest on it, press the finger against it, &c. Ask whether they would call this substance a liquid; let them give some reasons for their statement, and also their reasons for calling it a solid.

Point out that the substance is seen to be solid without knowing what substance it really is. Is it ice? Let them give some reasons for saying it is not ice, and apply some simple tests when necessary to illustrate such differences as the following:—

(1) It is not so clear and glass-like as the ice.

(2) It is not so cold to the touch, and does not melt when held in the hand.

Let a child hold it in his hand and state these facts; ask him to press it with his fingers, and say whether it is as hard as ice.

(3) It does not break so easily as ice when struck.

Drop a piece on the floor, also strike it with a knife-handle or hammer, and let the children state from previous experience what ice would do under these circumstances.

(4) It may be cut into shavings or pieces more readily than ice.

Cut off several thin shavings, lay them on a slate, and note that they do not melt like pieces of ice would do.

(5) It does melt, but not so readily as ice.

Warm a piece of sheet-glass (or tin) over a candle at some distance above the flame, so as not to smoke it, then lay on it some of the wax shavings. Let the children describe the wax as *melting*.

Incline the glass, and let the melted wax run over it; compare it with water, and lead them to call it a liquid, and to explain melting as a solid turning into a liquid when made warm enough. Set the glass aside to cool, and then point out the solid wax on the glass, and scrape off some shavings with the knife.

(6) Unlike ice the wax will burn.

The candle is made of wax; cut it, knock it, then light it and point to the melted wax at the top, as proving that it is the same substance as the other.

So that this is a very different substance from ice, and yet both are called solid bodies because in certain respects they are like each other and like other solid things. Let the children name the substance if possible, and enumerate the characters in which it agrees with ice and other solids. Let them name other solids.

LESSON VI.

CHALK AND SALT.

OBJECTS REQUIRED *Piece of chalk; sheet of paper; knife table-salt; empty tumbler; tumbler containing water spoon or glass rod for stirring; slate; blotting paper.*

ANALYSIS OF LESSON.

Piece of chalk is *one* solid body, divisible into smaller solids.

Ex.—*Break chalk into two, then many pieces.*
Crush several pieces into powder on paper.
Examine some powder on moist finger.

A powder is a collection of small solids—not liquid.

Ex. *Pour powder into empty glass to form heap.*

Powder mixing with liquid and settling to bottom.

Ex. *Pour water on powdered chalk and stir.*
Let liquid stand till chalk settles.

The salt is a powder; recognise.

Ex.—*Child take salt on moist finger and note the pieces*
Taste the salt.

Salt disappears in water, but is still present.

Ex. *Pour salt into water; stir.*
Taste drop of water.

Salt in water is liquid like the water—*dissolved.*

Ex.—*Pour out salt water; let drops fall from rod; soak up with blotting-paper.*

Examples of bodies which dissolve in water.

Compare dissolving of salt with melting of wax.

NOTES.

Subject of Lesson.—A solid body may be broken into very small pieces, and is then said to be in a state of *powder*, but still it is not a liquid. Some solids when placed in liquids disappear and become as the liquid—they are then said to *dissolve*.

Show the children a piece of chalk, ask whether it should be spoken of as a solid or a liquid body, and let them give reasons for their answer. Speak of it as a *piece* of chalk, *one* piece all parts of it being fixed together.

Break the chalk in two, and let the children state how they would then speak of it (viz. two pieces), and state also how these pieces differ from the original piece. Break it up into a number of parts, and lead the children to think of it still as a number of small solid pieces.

Then crush several of the pieces on a sheet of paper with a stone or knife-handle, and let them again describe it perhaps as *powder*. Question them to see if they understand the powder as being still composed of small solid pieces. Take up some powder adhering to the finger, and point out some of the separate pieces visible. Scrape the powder together into a heap on the paper, and then pour it gently into an empty tumbler. Let the children state whether this substance which can be poured so easily from the paper should be called a liquid. Point out that it may form a heap at the bottom of the tumbler as it did on the paper. Is that like a liquid?

Pour some water into the tumbler containing the chalk, stir it well, then let the children state how the liquid differs in appearance from the original water, the cause of the difference, and what they expect to happen if the water is allowed to stand still. (The children

would probably be able to state from previous observation that the powder will settle to the bottom.) Stir it up again, and then leave it to stand a little time until a layer of chalk is seen at the bottom.

Then take the salt, put out a heap on some paper, and let them say what it resembles; speak of it as a powder, and let them state again what a powder is. Let someone touch the salt with his finger and note the small pieces adhering to it. He might then be asked to state what powder he thought it was and how he could prove it; let him taste a little.

Pour some salt into another tumbler of water and stir. The children have probably seen salt put in water before; can they say what will happen? Let them state whether they observe anything different from what was observed in the case of the chalk. Note that the salt disappears and does not again settle down (stir once or twice more if necessary). Where, then, is the salt? Let them state how they could ascertain if the salt were really in the water—*e.g.* by tasting it. Let a child taste a drop of the water taken out on a glass rod or clean pencil.

Take another drop on the end of the rod, and let the children state what the drop is composed of—viz. salt and water; pour out some of the liquid into the other tumbler, and ask what was poured out—viz. salt and water. Soak up with blotting-paper some drops of the liquid which have fallen on a slate, and ask what has run into the blotting-paper.

Point out that these facts show that the salt has become a liquid and mixed with the water; or, as it is generally described, the salt has *dissolved* in the water. Let the children give examples of other bodies which will dissolve in water—soda, sugar, soap, &c. Remind

them that the wax in the last lesson was turned into liquid; let them give the name—*melting*—and state what caused the wax to melt. Call attention to the difference between melting and dissolving, and let them give examples of each.

LESSON VII.

STEAM.

OBJECTS REQUIRED—*Tumbler of water; small tin dish (not soldered); spirit-lamp, with support for dish; dry tumbler; slate; glass rod (or pencil).*

ANALYSIS OF LESSON.

Questions on changes in water, ice, and wax.

Conversion of water into *steam*.

Ex.—*Evaporate water in tin dish over lamp.*

Contrast steam with liquid water:

(1) Great and indefinite expansion.

Ex.—*Point out steam spreading in all directions.*

(2) Parts do not hold together.

Ex.—*Take drop of water on rod.*

(3) Bodies move easily amongst it.

Ex.—*Move hand and slate in steam.*

Steam called a *vapour*—water-vapour.

Steam converted again into water on cooling.

Ex.—*Hold dry cold tumbler in steam; rub finger on sides.*
Hold slate over dish till drops are formed.

Liquid disappears as vapour is formed—'evaporates.'

Ex.—*Continue heating till liquid all evaporated.*

Water-vapour in breath.

Ex.—*Breathe on cold slate.*

Power of steam from kettle; steam-engine.

NOTES.

Subject of Lesson.—Solid and liquid bodies having been examined, and solid bodies having been seen changing into liquids, steam is now taken as an example of those substances formed when liquids are further heated. The vapour or gas differs in many characters from both liquids and solids.

Commence with a few questions on water, the reasons why it is said to be a liquid, how it changes when it turns to ice, and how the ice can be turned again into water. Let them also state how wax may be turned into a liquid, and how it is then different from the solid wax.

Put a little water in a small tin dish (a dish stamped out and not soldered should be used) and support it over a small spirit-lamp—such, for example, as those metal lamps (often called 'stoves') with supports attached for supporting a small kettle or dish. (Great care must be taken in the use of the spirit on account of its very inflammable nature.) Before lighting the lamp give the children an opportunity of describing from previous observation how water changes when heated. Then light the lamp and note the formation of something, which, instead of remaining in the vessel with the water seen there, comes away and spreads about indefinitely in all directions, mixing with the air and becoming invisible. Speak of this as *steam* and contrast it with the water, directing attention to such facts as :

(1) It spreads indefinitely, while the water only fills up a certain part of the vessel and remains there.

(2) While the water holds together to form 'drops' (take a drop out on a rod and place on a slate), this sub-

stance does not seem to hold together at all to form either pieces or drops.

(8) The hand or a slate may be moved quite easily through it and amongst it without feeling any appreciable hindrance.

Then explain that this substance which thus spreads, does not hold together, and permits such easy movement through it, is called *vapour*—water-vapour. Let the children state what has caused the water to change into vapour ; and then point out that heat turns solid pieces of ice into liquid water, and drops of liquid water into a mass of water-vapour.

Hold a cold dry tumbler in the steam, and let the children note the water formed on the sides ; let some of them rub their fingers on the glass and show that they are wetted. Hold a slate in the steam until it has large drops of water formed on it, and explain that when the hot vapour touches the cold glass or slate, it becomes cold itself and turns into water again.

But if the water is turning into vapour which passes away, what difference would they expect to find in the quantity of water in the vessel? And what will be the result if the heating is continued? Continue heating the vessel till the water has all disappeared, and let the children again explain what has become of the water, where it is, and in what form. Speak of the water as having *evaporated*—i.e. turned into vapour.

Breathe on to a dry slate until drops of water are visible ; let the children try to explain how these are formed. Point out that no water is visible in the breath, and that it must therefore have been water-vapour which came out with the breath on to the cold slate.

The children might be led, in conclusion, to state what they have observed regarding the steam from the

kettle—how it sometimes comes rushing with great force from the spout or lifts up the lid ; and the teacher might connect these facts with the steam-engine, in which steam is formed in a large boiler, and in trying to push its way out moves certain rods and wheels and so does useful work.

LESSON VIII.

SMOKE.

OBJECTS REQUIRED—*Tumbler, with cover of cardboard; piece of thick brown paper to make smoke; matches; slate; pencil.*

ANALYSIS OF LESSON.

Questions on water changing into steam, and differences between liquid and vapour.

Ex.—*Burn small piece of brown paper; note part disappears.*

Suggestion that something like vapour formed.

Ex. *Put smouldering brown paper in covered tumbler; let children describe.*

Resemblances between smoke and steam:—

(1) Not in pieces or drops.

(2) Spreads to fill vessel and would spread further.

Ex. *Remove cover from vessel for instant.*

(3) Easy to move bodies amongst the smoke.

Ex.—*Put pencil and move hand in escaping smoke.*

Not like steam in every respect.

• **Ex.**—*Hold slate over tumbler of smoke.*
Note strong smell of the escaping smoke.

Smoke, steam, and similar substances called *gases* (some also 'vapours'); enumerate characters of gases.

Gases differ among themselves in visibility, smell, &c. Ex

Dirt from smoke on glass; smoke and soot from fires.

NOTES.

Subject of Lesson.—Water having been studied under the forms of ice, water, and steam, the differences between gases (or vapours) and solids and liquids are again considered in connection with smoke (really a mixture of hot air and gases with fine particles of soot), which has the advantage of being visible. The lesson will also serve to show that gases differ among themselves, just as solids and liquids were found to do.

Question the children on the manner in which water changes when heated, and the respects in which the vapour formed differs from the water. Remind them also that the liquid disappears as it turns into vapour.

Burn a small piece of thick brown paper and note that it also in large part disappears; and suggest that, perhaps, like the water, it has turned into something which has spread itself about and cannot well be seen. Take another piece of paper, light it, and then blow out the flame, saying that you do not wish it to burn so fast; then put the smoking paper into a clean dry tumbler, and cover over the top with a piece of paper or cardboard.

Let the children give the name for the substance which they see filling the tumbler, and say where it comes from, and also whether it is in any respects like the steam they talked about in the last lesson. Lead them to observe—

(1) That, like the steam, it is not in drops or pieces which hold together.

(2) That it spreads out to fill the vessel, and would spread farther if it could (remove the cover for a moment).

(3) That it is very easy to move the hand or any-

thing through it (put a pencil in amongst it, and move the hand in the escaping smoke).

Ask them to describe how steam changes when it is made cold. Put a slate over the mouth of the tumbler containing the smoke (not freshly made, however,) for a few seconds; show it to the children, and let them state how smoke differs from steam. The smoke, then, is evidently not exactly like steam, and is different in other respects—e.g. it has a distinct and strong smell which is noticeable when the smoke spreads about the room, whereas the steam from the kettle, &c., has no smell.

Substances which spread about so readily in all directions, which are not in pieces or drops holding together, and which permit of such easy movement through them, are called *gases* (and some also *vapours*)—such as steam, smoke, and the substance which we burn as it issues from the gas-pipes. But, while these gases are alike in some respects, they are not alike in everything—e.g. some cannot be seen, others can; some have a distinct smell, others none; some can be burnt, &c. Let the children give examples of each.

Then, in conclusion, let the children state the circumstances under which smoke is formed; from what substances they have seen it formed; what is disagreeable about smoke, &c. Point out that, although the smoke does not wet the sides of the glass, it probably makes them dirty; question the children as to what becomes of the smoke from the fire in the grate, and whether that smoke makes any place dirty. The soot in the chimney, then, is something like the dirt on the sides of the glass—little solid pieces from the burning coal or paper which make the smoke thick so that we can see it.

LESSON IX.

THE AIR.

OBJECTS REQUIRED.—*Brown paper (for smoke); tumbler and cover; matches; sheet of thin paper; slate; thin paper bag (large size); hollow indiarubber ball with opening; tumbler nearly full of water; small piece of cork; wine-glass (or small, wide-mouthed bottle).*

ANALYSIS OF LESSON.

Revise characters of gases.

Ex.—*Put smouldering paper in covered tumbler.*

Some invisible substance around us spoken of as *air*.

Proofs of existence of invisible *something* by its effects.

Ex.—*Hold up sheet of paper and push aside with finger; then blow aside.*

Blow against hands, paper, dust, &c.

Fan air with slate against face, paper, &c.

Blow into paper bag and note filling out.

Close mouth of bag and press sides together; open mouth of bag, and again close and press.

Open bag and press sides together: explain different effect.

Open out bag, close its mouth, and again press sides.

Squeeze indiarubber ball and feel air coming out; let it blow paper, &c.; let ball fill again, and repeat several times.

Float cork on water; place inverted wineglass over cork and force to bottom of water; note cork and water kept out of glass.

This something—*air*—present everywhere; proofs.

It has characters of a gas; enumerate.

NOTES.

Subject of Lesson.—The purpose of the present lesson is to show that the air is a real substance, with certain general characters similar to those of the steam and smoke previously considered—that is to say, it is a gas (or rather a mixture of gases).

Put a piece of smouldering brown paper in a covered tumbler and let the children describe some of the facts they observe, especially the manner in which the smoke spreads itself about to fill the vessel. Let them state what they learnt in the last lesson to call such substances, and what other characters of gases were then noticed.

Remind them that persons often speak of something about us called the air—e.g. of a bird or a kite being 'up in the air,' 'a breath of air,' &c.—but that we cannot see the substance, nor has it any smell like that invisible substance which we burn and call 'gas' or, more properly, 'coal-gas.'

Then proceed to show in several ways that there is *something* present which, though invisible, is able to produce certain definite effects.

(1) Hold up a sheet of paper by one corner and push it aside with the finger; then, letting it hang straight again, blow against it, and lead the children to understand that it moves aside because *something* pushes it. Blow against your own hand, and let several children do the same against theirs; also blow against the surface of the water in the tumbler or a small piece of paper lying on the table, and lead the children to state that they feel *something*, or that *something* moves the bodies.

(2) Fan the air (with a slate) against your own face

and then against the faces of the children; and also fan the air so as to move pieces of paper, &c., on the table. Let the children themselves describe and explain the effects.

(3) Take a thin paper bag, close the mouth except a very small opening, and blow into the bag to fill it out. Let the children describe what they see, what it is that has gone into the bag, and whether the substance spreads about the bag in all directions like the smoke was seen to do in the tumbler, &c. Close the opening, and press the bag to show that *something* is inside it, filling it out. Open the mouth of the bag wide to show that nothing is to be seen in it; then close it again, and by pressing the sides show that the air is still in it. Then again open the mouth of the bag and press the sides together; ask the children to explain why this may readily be done under these circumstances. Open the bag wide, and then close the mouth and press it to show that the air has gone in again.

(4) Take a hollow indiarubber ball with a small hole in the side, and repeat several of the experiments with it, letting certain children feel the air coming out of the hole when the ball is squeezed; note also how the air goes in again and swells out the ball, and how it may again be squeezed out, and so on.

(5) Put a small piece of cork on the water in the tumbler (which should not be quite filled), and invert a wineglass over the cork and push it down into the water to the bottom. Let several children observe that the cork and the water do not go into the tumbler—something keeps them out and pushes them farther and farther down in the water. Let them describe clearly what they observe, and try to explain it.

Then point out that wherever we go—into whatever

room or building or country—on hills, in valleys, &c., we find this something—called *air*—present. We feel it when it strikes against us—as when the wind blows, or when we fan ourselves—it fills out bags, balls, &c. It seems to spread over everything and into all places, like the smoke and the steam; and yet we can readily move our hands about in it without feeling it stop us. What, then, ought it to be called—a solid substance, a liquid, or a gas?

LESSON X.

A PAIR OF BELLOWS.

OBJECTS REQUIRED *Small pair of bellows; tumbler; brown paper for smoke; matches; hollow indiarubber ball (used in last lesson).*

ANALYSIS OF LESSON.

Name of instrument; uses.

Manner of use.

Ex. *Let child work bellows.*

Air comes from bellows when worked; proofs.

Ex.—*Hold hand in front of nozzle; blow paper, &c.*

Compare bellows with indiarubber ball of last lesson.

Ex.—*Repeat experiments with ball.*

Where does air enter bellows?

Ex.—*Stop nozzle lightly with finger and open bellows.*
Point out other opening; put finger in.
Place opening of bellows over tumbler of smoke; work bellows: note smoke driven from nozzle and its spreading.

Use of little door (valve) guarding opening.

Full account of working of bellows.

Advantage of blowing air into fire.

Materials of bellows; advantage of soft leather sides, iron pipe, &c.

NOTES.

Subject of Lesson.—The working of the common ellows serves to illustrate again several characters of ir and gases previously noted; and the construction nd mode of action of the instrument are simple, readily iscertained, and easily understood.

Let the children first recognise the instrument, and state the purposes for which it is used. Ask some child to show the manner of working the bellows.

Then, while working the bellows yourself, let the children try to describe what happens. When they have been led to say that air comes out, let them point out the place where it comes out; and let them describe several methods (similar to those used in last lesson) of proving that something does come out at that place, even though it cannot be seen e.g. hold the hand against the nozzle, blow against paper, &c.

Show them the indiarubber ball used in the last lesson; and, after letting them describe what was then done with it, lead them to compare it with the bellows. Let them state how it is that, after pressing air out of the ball once, it can afterwards be done over again as often as you like. Then explain that such must be the case with the bellows; and let them, if they can, point out where the air gets in. Let a child stop up the hole at the nozzle with his finger, and show that air still gets in, so that it must be by some other opening. Ask them to point out this other opening, and let a child put his finger into it, and raise the little door inside which covers the hole.

To prove that the air can push its way in at that opening, put a piece of smouldering brown paper in a tumbler, and cover the vessel with the bellows, so that

LESSON X.

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ANALYSIS OF LESSON.

Name of instrument; uses.

Manner of use.

Ex. *Let child work bellows.*

Air comes from bellows when worked; proofs.

Ex.—*Hold hand in front of nozzle; blow paper, &c.*

Compare bellows with indiarubber ball of last lesson.

Ex.—*Repeat experiments with ball.*

Where does air enter bellows?

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Use of little door (valve) guarding opening.

Full account of working of bellows.

Advantage of blowing air into fire.

Materials of bellows; advantage of soft leather sides, iron pipe, &c.

NOTES.

Subject of Lesson.—The working of the common bellows serves to illustrate again several characters of air and gases previously noted; and the construction and mode of action of the instrument are simple, readily ascertained, and easily understood.

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To prove that the air can push its way in at that opening, put a piece of smouldering brown paper in a tumbler, and cover the vessel with the bellows, so that

the opening in the side of the bellows lies over the mouth of the tumbler. When the tumbler is full of smoke work the bellows as it lies, and let the children describe and explain what they see—viz. that the smoke goes into the bellows at the opening covered by the little loose door, and then is pushed out at the pipe. Also lead them to observe and describe how the smoke spreads itself out on leaving the pipe.

Point out that this little door will fall down as soon as the smoke or air has gone through, and lead the children to explain the effect of that arrangement when the sides of the bellows are pressed together.

Then let several children give, in their own words, a connected and continuous description of what takes place during the working of the bellows. Remind them of what they have before learnt, that air and other gases spread about and push their way into all spaces where they can.

It might be explained that the fire must have air in order to burn, and then the children led to explain why it is sometimes an advantage to blow a fire. They might also be asked to name the substances of which the bellows are made, and to explain why the sides are made of soft leather, and the pipe of iron.

LESSON XI.

SOLIDS, LIQUIDS, AND GASES.

OBJECTS REQUIRED—*Tumbler filled with smoke from brown paper, and covered; tumbler partly filled with water, and covered; tumbler containing irregularly-shaped stone, and covered; plate (or slate).*

ANALYSIS OF LESSON.

Name substances in tumblers: necessity for vessel or cover?

Ex.—*Set covered tumblers containing smoke, water, and stone in view of children.*

Which substance is liquid? How different from others?

How describe other substances their differences?

Note different results when taken from vessel.

Ex.—*Take cover from smoke; note spreading.*
Pour some water on plate or slate.
Take stone from tumbler with fingers, and replace again.
Invert tumbler containing stone.

Application of above principles to natural phenomena:—

Liquid.—Water in ponds, lakes, &c.; waves.

Solid.—Rocks forming hills, cliffs, &c.

Gas.—Air, wind.

NOTES.

Subject of Lesson.—This lesson is arranged for the purpose of revising the principal facts, observed in the preceding lessons, which lead us to distinguish certain bodies as solids, others as liquids, and others, again, as gases. These principles are then applied to illustrate and explain certain geographical facts.

Take three tumblers covered with cardboard—one filled with smoke, one half-full of water, and one containing an irregularly-shaped piece of stone, and let the children name the substance present in each. Let them also state in which case it is really necessary to enclose the substance in a vessel, and in which case it is necessary to have the vessel completely closed.

Let the children point out which substance they would call a liquid, and explain how it differs from each of the others. Then let them say by what names they would speak of these other substances, and give their reasons for so distinguishing between them. Lead them, by questions if necessary, to describe the smoke as completely filling the vessel, moving into all parts of it; the water as filling out one part of the vessel, leaving no spaces at the sides, and having no hollows or hills on its surface; the stone as having all its parts fast together, so that it does not need to rest against the sides of the vessel, and having some parts standing up above the rest and leaving spaces round its sides.

Take off the cover from the vessel containing the smoke, and let the children describe the manner in which some smoke leaves the rest and spreads about in the room; pour some water from the tumbler on to a plate, and note how readily the parts move, and how some comes away from the rest and spreads out on the plate. Take

the stone out of the vessel with the fingers, and put it in again; then invert the tumbler containing the stone, and let the children describe the difference they observe between the result in the case of the stone and the results in the other cases—viz. that all the parts of the stone move together and remain fast together, so that it lies steadily in one place on the table without spreading itself out.

Remind the children—draw from them as far as possible—that they often see water in fields, parks, &c., and that it lies in hollow places, spreads out to the sides, and has no irregularities on its surface when it is still; thus we have *ponds, lakes, seas,* &c. And since water is so easily moved we often find it disturbed so as to form *waves*, as when moved by the wind, by a moving boat, or by a stone thrown into it.

Let them describe the ground as solid, and compare it to the stone as being able to stand with some parts above and others below the rest, and let them give examples—e.g. *hills, banks, cliffs, valleys.*

Lastly, remind them of the air which has spread over all the earth, covering all the hills, filling all the valleys, and occupying all spaces where there is nothing to keep it out. Remind them also that air may easily be moved (let them state several ways of moving it), and that then it may be felt, or we may see it moving bodies (trees, &c.) against which it strikes; and we then speak of it as *wind*.

LESSON XII.

A POKER.

OBJECTS REQUIRED—*An ordinary iron poker; small block of wood, or thick piece of board; wooden rod (pointer) of about same size as poker.*

ANALYSIS OF LESSON.

Name and uses of object.

Heavier than similar piece of wood.

Ex.—*Let child hold poker in one hand, pointer in other; then hold each horizontally by one end.*

Name material; advantages for poker.

(1) Iron does not burn; compare with wood.

(2) Does not easily melt; compare with wax, &c.

Other iron structures about fire—bars, oven, &c.

(3) Hardness of iron an advantage; describe breaking coal.

Ex.—*Strike wood with point of poker; note mark on wood, and that iron is unchanged.*

(4) Does not readily bend or break—strong.

Ex.—*Child try to bend poker.*
Strike poker with wood.
Lift chair or raise blackboard with poker.

Enumerate characters of iron noted.

Note rounded end (knob); bright appearance when clean; blackened point, &c.

NOTES.

Subject of Lesson.—In this and several succeeding lessons, one particular solid substance—iron—is examined in some of its applications, in order to ascertain some of its important properties, and to show how these fit it for the special purposes to which it is applied. In this lesson its hardness, strength, and the difficulty with which it is melted are the chief facts noted.

Let the children recognise and name the object—an iron poker—and describe its ordinary uses, viz. to remove ashes from the fire, and to raise or break pieces of coal in the grate.

Take a wooden pointer of about the same size as the poker and let a child hold it in one hand and the poker in the other, and state what he observes as to the weight. Then let him take each by one end and try to hold it out straight, and again describe what he observes as to the weight, and which is more easily and steadily held.

Let the children say of what material each of the bodies is made, and then lead them to state that a piece of iron is much heavier than a similar piece of wood.

Ask them next why a wooden poker is not used for the purposes before mentioned; let them state what occurs when wood is put into the fire, and what change takes place when the poker is left in the fire for some little time. Then let them express in a complete sentence this difference between iron and wood.

Question them next on the manner in which a rod of wax or a piece of ice would change if put into, or even near, the fire. Contrast the ease with which these solid bodies melt with the difficulty of melting iron; and point out the advantage of this property in connection with the use of iron, not only for pokers, but for other purposes

connected with our fires—e.g. bars of grate, oven, &c., letting the children themselves, if possible, suggest the names of these iron structures.

Let them next describe how the poker is used to break the coal, how the coal is struck with the point of the poker, and why it is the coal rather than the poker which breaks. Strike the end of the poker against a piece of wood; let several children examine both the wood and the poker to ascertain the effect of the blow, and then let them describe how the wood is marked and bent or broken at the point where struck, but that the iron is apparently not changed. Lead them again to explain what this observation shows as to the relative hardness of the two substances.

Let a child try to bend the poker; let another strike it with a stout piece of wood; and then the teacher lift a chair, and raise the blackboard or some other heavy body, by means of the poker. Lead the children to describe what all these observations show about the substance (iron)—viz. that it is very strong, and not easily bent or broken.

Then sum up the facts so far learnt about the substance of which the poker is made: it does not burn nor easily melt; is hard and strong, and will not readily bend or break; and it is heavier than a piece of wood of about the same size.

A short conversation on some other facts connected with the poker might follow, the children being led to observe, and where possible to explain, such facts as the following: the rounded end where the poker is to be held; the pointed and probably squared end which is put into the fire; the blackening of the latter end by soot, which comes off when it is touched; the bright appearance of the poker when properly cleaned, &c.

LESSON XIII.

A HAMMER AND NAIL.

OBJECTS REQUIRED —*Hammer; bright iron nail (e.g. 'wire' nail two or three inches long); poker; knife; block of wood; small wooden rod (such as a large match with head broken off); fair-sized stone.*

ANALYSIS OF LESSON.

Enumerate special advantages of iron for poker.

Compare nail with poker — shape, material, &c.

Ex.—*Test poker and nail between fingers.*
Try to scratch each with finger-nail and knife.
Strike each against wall or stone.

Use of nails; advantage of special shape and material—pointed, strong, and hard.

Ex.—*Child drive nail short distance into block.*
Try to hammer small wooden rod into block.

Parts of hammer; material of head and handle.

Iron best for head because hard and heavy.

Ex.—*Compare weight of head and handle in hand.*
Strike block and nail with head, then with handle.

Iron feels colder than wood.

Ex.—*Children touch iron and wood of hammer and describe.*

Substitutes for hammer—stones, &c.

Ex.—*Child knock nail in block with stone.*

Different shaped ends of head, &c.

NOTES.

Subject of Lesson.—A hammer and an iron nail are examined, mainly with a view to illustrate still further the characters of iron, and also how certain of its uses depend on the special properties of the substance.

Commence with some questions on the subject of the last lesson; leading the children to state again the facts then ascertained with reference to iron, and the manner in which certain uses of the poker are related to those facts.

Then show the children the large nail, and let them suggest any resemblances between it and the poker which may occur to them. Suggest the question (if not referred to by themselves) whether both bodies are made of the same material. Let them give some reasons for their statement, and test both the nail and poker in several ways to find out any resemblances—e.g. try to flatten each between the fingers, to scratch or mark each with the finger-nail, to cut each with a knife, also strike each against the wall or a stone.

Question the children as to the uses of nails, and the advantage of their pointed ends and broader heads. Let them describe how the nail is forced into wood (a child might be asked to drive the nail a short distance into the block of wood); and let them also state what would be the effect of trying to drive one piece of wood into another in that manner. Break the head off a match, and try to drive the nail-like piece of wood into the block. Lead them to state that the hardness and strength of iron enables it to be thus driven into softer substances.

The hammer should next be examined, and its parts (head and handle) pointed out, named, and their uses described. The children should be asked to name the

material of which each of these parts is composed, and to mention some differences between the materials. Let them also explain why wood would be unsuitable for the head—remind them of the way in which wood was marked in the last lesson when struck against iron.

Let several children in succession take the hammer into their hands and state which part of it is the heavier. Ask one of them to strike the block of wood first with the head in the usual way, and then, holding the head, again strike the block with the handle ; and let him state whether the harder blow can be struck with the heavier head or the lighter handle. Let them mention other purposes for which hammers are used—e.g. breaking coal, stones, &c.—and point out that for all these purposes iron is a better material than wood for the head of the hammer, being both heavy and hard.

Let a child lay his hand first on the wooden handle and then on the iron head, and state what he observes, and whether he could say without looking which substance he touched. Let several other children in the same way touch the iron and the wood to observe the colder feeling of the former as compared with the latter ; and then lead them from this observation to give one reason why a wooden handle is better than an iron one. Also let them give other examples of iron things having wooden handles.

Ask the children to describe how they would knock in nails, &c., if they had no hammer—e.g. by using pieces of stone ; and let them state what kind of a piece they would choose—a hard and heavy piece—and how they would use it. Tell them that in some museums they may see pieces of stone, formerly used as hammers when people could not get iron.

If any time remains such points might be noticed as the difference in form between the two ends of the head of the hammer, the use and advantage of such differences, and the manner in which the handle is attached to the head—probably by being tightly wedged in a hole.

LESSON XIV.

A KNIFE.

OBJECTS REQUIRED—*Table-knife; pocket-knife; small wooden rod (or lead pencil) to cut; block of wood or thick board; chalk; piece of string; small sheet of paper; sheet of glass; small piece of copper wire (or thin sheet copper).*

ANALYSIS OF LESSON.

Uses of knives.

Ex.—*Cut piece of wood or pencil to point.*

Compare knife with hammer; recognise blade as of iron.

Reason for different shape of iron in hammer and knife.

Description of knife-blade 'edge,' 'back,' rounded or pointed ends.

Ex.—*Draw outline of blades of each knife.*

Hardness of iron gives special advantage.

Ex.—*Press sharp point of wood against board to break, and contrast with nail.*
Press chalk against board to crush.
Press edge of paper sheet against board to bend.
Press point and edge of knife against wood.

Special hard variety of iron—*steel*—used for cutlery. Examples of cutting instruments.

Steel cuts some substances, not others; why? Examples of each.

Ex.—*Children cut wood, string, paper, and chalk.*
Try to press knife into glass or to scratch it.

Explanation of 'sharpening' knife against harder :

Elasticity of steel; other elastic substances.

Ex.—*Slightly bend table-knife and release;*
Try same with chalk, copper wire, &c.

Varieties of knives and general characters.

NOTES.

Subject of Lesson.—The hardness and strength of iron—especially in the form known as steel—render it exceedingly valuable for cutting instruments. A knife is taken as the most familiar example of such instruments, and is examined mainly with a view to illustrate these and other important properties of iron (steel).

Commence with questions as to the uses to which knives may be put, and the manner in which they are used. Sharpen a pencil or piece of wood to a point to illustrate the manner of use.

Let the children say if the knife is in any way like the hammer—e.g. there is a handle and the other part is made of iron. Let them give some reason for the latter statement, and also describe and explain the difference in form between the head of the hammer and the blade of the knife.

Ask some child to point out the particular part of the knife used to cut with. Let them give the name 'edge,' and also the name for the other edge of the blade—the 'back.' Ask them to describe and explain the difference between those two parts—e.g. the cutting edge is thin and sharp, the other thick and strong. Show the edge and back both on a table-knife and a pocket-knife, and let them compare the pointed end of one blade with the rounded end of the other. Draw outlines of the two forms of blade on the blackboard.]

Press the sharpened piece of wood against the blackboard, or a block of wood, till the point breaks. Let the children describe what has happened, and explain why the pointed wood breaks while a nail would penetrate the board. Press a piece of chalk against the board, and lead them to observe how it is crushed and broken,

and let them again give the reason. Press the edge of a sheet of paper against the board, and let them note and describe the result—e.g. the bending of the paper.

Then press the point and the edge of the knife against the same surface as before, and note the different result—how it penetrates and does not bend; let them state what these experiments prove about the iron. Tell them that knife-blades (and other things to be used for cutting purposes, as scissors, axes, &c.) are made of a particularly hard kind of iron known as *steel*.

Let some children use the knife to cut wood, string, paper, chalk, &c., and then inquire if every substance may be penetrated or cut with the knife. Try to press the point of the knife into a piece of glass, and draw the blade over the glass to show that it does not cut or scratch a mark on it. How do they explain this fact? Ask them to name some other things which are too hard to be readily cut or penetrated by the steel knife.

Some substances are so hard as to scratch and mark the steel. Remind them how knife-blades are sometimes rubbed against stones to 'sharpen' the edges; illustrate the manner in which this is done by rubbing the knife on the board; and lead them to understand that pieces of the steel are scratched and worn off so as to make the edge thinner.

Slightly bend the blade of the table-knife and let the children describe what you have done; then release the blade and let them note how it straightens itself again. Repeat this several times, and point out how convenient it is to have the knife made of a substance which keeps its shape so well. Say that substances which thus straighten themselves after being bent are said to be 'elastic' substances; let them name any others they know—cane, whalebone, &c.—and show that some, such

as chalk and wood, cannot be bent much without breaking, while others again—e.g. copper wire—may readily be bent, but remain so.

If any time remains, a short conversation might be held as to the advantage of having handles to knives, the materials used for handles, and the manner in which they are fastened on to the blade; the advantage of having knives which are intended to be carried about in the pocket made so as to close, and the necessity for the little groove on the side of the blade in the pocket-knife by means of which it is opened.

LESSON XV.

IRON AND STEEL.

OBJECTS REQUIRED *Poker; hammer; large nail; knife; large sewing needle; piece of rusty iron; spirit-lamp* (or *gas flame*)*; matches; small sewing needle.*

ANALYSIS OF LESSON.

Name iron objects of previous lessons.

Describe uses,—special advantage of iron for each instrument.

Enumerate facts (*write on board*) learnt about iron *strong, hard, heavy, not easily melted, cold feeling, bright, &c.*

Explain term 'description,' describe needle without giving name.

Ask child to describe needle, &c., and illustrate facts as named.

Advantages and uses of steel.

Iron is bright only when clean; often dull (after heating).

Ex.—*Show dull, black end of poker, nail, hammer, &c. Heat bright needle (held in wood) in flame.*

Another change—'rusting' of iron in damp place.

Ex.—*Show rusty iron, and let children examine and describe.*

Protection of railings, spouts, &c., by paint.

Enumerate characters of iron.

NOTES.

Subject of Lesson.—The principal facts ascertained in preceding lessons as to the nature and properties of iron (and steel), and its application to various useful purposes by reason of those properties, are in this lesson recapitulated and brought together so as to form a brief general description of that substance. The change in the appearance of the substance when heated or exposed to damp air is also briefly pointed out.

Show the children the various objects made of iron (and steel) considered in previous lessons— poker, hammer, nail, knife—let them name the objects, and the material of which they are made.

Then take the poker, hammer, nail, and knife separately, and let them state the special use of each, and explain why iron is so suitable a material for the purpose. Write on the board the various characters as they are mentioned e.g. that iron is *strong, hard, heavy, elastic, usually cold to the touch, bright when clean, does not readily melt*, &c.

Explain that this is said to be a 'description' of the substance; that persons might, perhaps, know from this description what substance was being spoken of even though its name was not mentioned. Illustrate this further by giving them a 'description' of a sewing needle (not mentioning its name)—e.g. a little rod of iron shaped something like a poker, only much smaller in size, with one end coming to a very sharp point, and instead of a knob at the other end having a hole through it. Let them guess the name of the object you have been describing; then show them the needle and let some of them give the description, holding the needle

in their hands and pointing out the various characters as they proceed.

Question them to ascertain if they remember the special name given to that kind of iron which can be made so hard—steel—and some uses to which it is put on account of its hardness.

Next direct attention to the colour and appearance of the iron, as shown in the clean knife-blade, hammer-face, &c. Point out that the end of the poker which has been in the fire has not the same bright grey appearance, but is black (even when the soot and dirt are rubbed off). Probably the head of the hammer, with the exception of the face, has a similar black colour, and so have some nails. Hold a bright sewing needle (stuck in a piece of cork or the end of a match) in the flame of the gas or, better still, of a spirit-lamp for a few seconds, and note that, after being wiped clean from any soot, it has a black surface. The bright grey colour of the iron is, therefore, only seen when the substance is quite clean, and has been ground or polished.

Show them a rusty nail or other piece of rusty iron, and question them to ascertain whether they have observed under what circumstances that change takes place—viz. when the iron is exposed to damp air. Let them, if they can, give the name 'rust,' describe its colour, and state how some iron things, such as iron railings, spouts, &c., are usually prevented from rusting —viz. by covering them with paint.

Lastly, let several children give, in as connected a form as possible, a statement of the various facts they have learnt about iron. [They might some time afterwards be asked to write down such a statement on their slates.]

LESSON XVI.

LEAD.

OBJECTS REQUIRED—*Flat piece of lead with bright surface; piece of lead (pipe) with dull surface; table-knife; hammer; block of wood; spirit-lamp; matches; iron spoon; piece of lead to melt; old slate.*

ANALYSIS OF LESSON.

Characters common to iron and substance shown—cold to touch, &c.

Ex.—*Children hold (bright) lead in hand.*

Difference between the substance and iron—softer.

Ex.—*Press end of knife into lead; cut off thin pieces.*
Press shaving of lead between fingers and against board, &c.
Scratch and mark lead with finger-nail.

Give name of substance.

Lead is softer than iron.

Ex.—*Strike (bright) lead with hammer and note effect on each.*
Strike edge of hammer with lead.

Lead not elastic like iron.

Ex.—*Bend knife-blade and release.*
Bend piece of lead.

Recognise dull piece of lead.

Ex.—*Child test it with knife, finger-nail, hammer; &c.*

Compare tarnishing of lead with rusting of iron.

Ex.—*Scrape and cut dull lead.*

Lead melts more readily than iron.

Ex.—*Melt lead in iron spoon; pour out on slate, and note bright, clean appearance.*

Enumerate facts observed about lead.

NOTES.

Subject of Lesson.—One metal—iron—having been somewhat carefully examined in previous lessons, another metal—lead—is now examined and compared with iron to show that, while there are certain resemblances between them, there are also characteristic differences which lead us to regard them as two distinct substances.

Lead the children to state again the principal facts observed in previous lessons about iron. Then show them a clean, bright piece of lead (previously prepared by melting some lead and pouring it out on a stone or old slate), and let them say if it looks at all like iron —e.g. like the hammer-face or knife-blade. Let some children take it in their hands, and state whether it reminds them of any of the particulars noted about iron. Lead them by these means to state that, like iron, it has a bright grey colour, a comparatively great weight, and a similar cold feeling.

Further examination may show that it is not like iron in everything. Press the end of a knife into the lead, and also cut off pieces from the edge. Let the children state what this shows about the lead—viz. that it is softer than iron; and confirm this statement by pressing a thin piece of lead (such as a piece cut off with the knife) between the fingers, against the board, &c., and noting how readily it is bent. Illustrate this fact also by letting some children observe how readily they can scratch and mark the surface of the lead with their finger-nails. Compare the lead in these respects with iron, and give them the name of the substance.

Then with a hammer strike the lead, as it lies on a block of wood or stone; and let the children examine both the lead and the hammer afterwards to see whether

either has been altered. Also strike the edge of the hammer with the lead, and let them again observe which has been changed. Then let them state what is proved by this flattening and marking of the lead, while the iron remains unaltered—viz. that lead is not so hard as iron.

Question the children about what was observed on bending the knife-blade; repeat the experiment, and then let them state what term was used to describe this property. Let a child bend the sheet of lead and observe that it remains bent, so that lead appears to be not elastic.

Take a piece of lead, such as a piece of old lead pipe, with a dull surface, give it to some child, and ask whether it is lead. Let the child give some reasons for thinking it is lead; testing it with the knife, the hammer, and the finger-nail in the same manner as the other piece was tried.

Then call attention to the difference in appearance between this lead and that first shown, and remind them how in the last lesson the iron was found to change its appearance when made hot or when left lying about in a damp place. Scrape off a portion of the surface and cut off a piece of lead to show the bright colour of the fresh metal. Although lead slowly alters its appearance and loses its brightness, it does not become black or brown as iron does, but of a dull grey. (Let the children themselves name the colours.)

Remind the children of the previous statement that the poker is made of iron because it does not readily melt. Let them name some substances melted in previous lessons; then place a small piece of lead in an iron spoon and hold it over the flame of a spirit-lamp (or small spirit-stove) till the lead melts. (Point out that

the iron spoon does not melt.) Pour the melted lead out on an old slate, and note the bright, clean appearance.

Lastly, let the children enumerate the facts they have learnt about lead, and state in what respects it resembles iron and in what respects it is different.

LESSON XVII.

SILVER.

OBJECTS REQUIRED *Clean, bright shilling and half-crown (or crown); several other silver coins; piece of clean, bright lead; table-knife; pin.*

ANALYSIS OF LESSON.

Compare substance of shilling and of half-crown; name.

Recognise clean, bright lead; how like silver and iron?

Differences between silver and lead.

> **Ex.**—*Bend lead and try to bend coin.*
> *Scratch lead with finger-nail; try coin.*
> *Drop lead, then coin; note and describe sound.*
> *Drop lead on edge and note flattening; drop coin on edge.*

Difference between iron and silver.

> **Ex.**—*Slightly scratch coins with pin; try to scratch knife-blade.*

Questions on rusting of iron and tarnishing of lead.

Bright permanent white lustre of silver; use.

> **Ex.**—*Find dates on coins and calculate age.*

Enumerate characters common to silver, lead, and iron; also differences.

Silver coins.

NOTES.

Subject of Lesson.—A third metal—silver—is examined in this lesson and compared with the two previously studied, so as to lead up to a general lesson on the class of substances known as metals. Certain facts connected with the application of silver to coinage are also considered.

Show the children a clean, bright shilling. Let them name it, describe its use, and, if they can, also give the name of the substance of which it is made. Then show them another silver coin, and let them say whether its substance is at all like that of the shilling, and in what respects. If it is just like the substance of which the shilling is made, what would they call it?

Show them again a piece of bright, clean lead, and let them suggest several means of testing it—cutting, scratching, bending, &c.—to satisfy themselves that it is lead. Then ask them if the silver is at all like the lead, and in what respects. Let a child take the half-crown in his hand, observe the cold feeling (if the coin has been lying for some time on the table), the comparatively great weight, and the bright, shining appearance. Point out that all these facts were previously noted both of iron and lead, at least when clean pieces of those substances were examined.

Then let the child bend the lead, and afterwards try to bend the coin; let another child scratch the lead with his nail, and try to scratch the silver. Ask them to state, in their own words, the differences they have observed between the lead and the silver.

Drop the piece of lead on the floor or table, then drop the coins, and let the children observe and describe the difference in the sounds—the dull heavy

sound of the lead, and the clear ringing sound of the silver. Describe and explain the manner in which the genuine character of a coin is tested by this ringing sound when it falls.

Again drop the lead on one of its thin edges, and let the children observe how readily it is flattened or bent; let them examine the coin after being dropped to note that it is not so bent. Let them state what this observation proves. (The silver of the coinage is slightly hardened by admixture with a very small proportion of copper, but this need not now be referred to, as pure silver is appreciably harder than lead.)

With a pin make a slight scratch on the coins, and then let a child try with the pin to scratch the blade of a knife. Let them again state what these observations show—viz. that while silver is harder than lead, it is not nearly so hard as iron.

Question them as to the manner in which pieces of iron and lead change in appearance when exposed for some time to the air. Let some child find and read the date on the coins. Explain that it indicates the year when the silver was made into the coin, and calculate how long ago that was. (Show them a coin dated many years back.) Then point out that the silver does not become rusty like the iron, or very dull like the lead; and explain that this fact, coupled with its beautiful bright white appearance when quite clean, makes people admire it. Let them name several other articles which they have seen made of silver—e.g. watches, chains, brooches.

Ask them to enumerate the characters in which silver agrees with iron and with lead, and then certain characters in which it differs from each of those two

The remaining time might be spent in a short conversation about the various silver coins in use, letting the children name as many as they can, and showing them examples of each. Briefly explain the relative values—the fact that a shilling contains twice as much silver as a sixpence, a florin twice as much as a shilling, and so on. The impression of the queen's head and the queen's name might be pointed out on each coin. Also the manner in which the coins wear smooth by long use might be pointed out on any of them that show it distinctly, and a comparatively new and perfect coin might be compared with an old worn one of the same denomination.

LESSON XVIII.

METALS.

OBJECTS REQUIRED—*Clean, bright piece of lead; bright piece of iron (knife-blade or key); clean piece of sheet copper and piece of paper same size; coil of copper wire; gold; bright tinned iron sheet; mercury (quicksilver) in bottle.*

ANALYSIS OF LESSON.

Revise characters common to iron and lead; then iron, lead, and silver.

Differences between copper and above substances; points of agreement.

Ex.—*Children hold copper in hand; compare weight with paper.*

General characters of *metals.*

Ex.—*Show gold and tin; compare with other metals. Show specimen of mercury; note weight, &c.*

Mercury is liquid—but has characters of metal; compare with melted lead.

Enumerate various metals and their uses.

Ex.—*Show copper wire, sheet copper, &c.*

Enumerate general characters of metals, and differences (colour, effects of air, &c.).

NOTES.

Subject of Lesson.—This lesson is intended to lead the children to associate together certain substances, such as the iron, lead, and silver recently studied, under the general name of *metals*, on account of their possessing certain special characters in common. It will also serve to recall and enforce certain facts learnt in the course of recent lessons.

Taking a clean, bright piece of iron and a clean, bright piece of lead, let several children examine them sufficiently to be able to name the substances. Then let them point out the characters in which both agree—viz. both have a bright, shining appearance, are usually cold to the touch, and are heavier than most other substances of similar size.

Then show them a shilling, and let them tell you from remembrance of the last lesson some particulars of the substance of which it is composed, and the name of the substance. Draw special attention to the characters in which it agrees with lead and iron.

Next take a sheet of clean, bright copper, and let the children state how it differs from the iron, lead, and silver; but again point out that it is like them in the respects above mentioned. Let some children touch it and hold it in the hands, comparing its weight with that of an approximately equal sized sheet of paper or wood.

Explain that all these and other similar substances are called by the name of *metals*, and are most useful substances. Show them other examples of metals e.g. a gold coin or ornament, and a piece of common sheet tin (really a sheet of iron coated with tin). Let them in each case note how the substances differ from the other

metals in colour, but still have the general characters mentioned.

A specimen of mercury (quicksilver) in a bottle should next be shown and the children asked why it was necessary to put it in a bottle, and what name they give to substances which move so easily when shaken, and spread out of themselves when not enclosed. Ask them if this liquid is at all like the metals previously examined—note its bright, shining appearance; let a child hold the bottle to observe the comparatively great weight, and also touch the liquid with his finger to observe its cold feeling. This substance, although a liquid, evidently should be considered a metal. Remind the children of having seen lead as a liquid very similar in appearance to mercury; let them describe how the lead was made into a liquid, and melt some again if necessary. Tell them that in very cold countries mercury is sometimes solid, like lead, and melts again when it becomes warmer.

Then let them name the several metals they have seen, and give examples of various uses to which some of them are put knives, pokers, nails, money, kettles, pans, gas and water pipes, &c. Explain that most of these metals may be rolled or hammered into sheets, or drawn out into wire; show a piece of copper wire, without naming it, and let the children state of what metal it is composed.

But, as they have seen, the metals are not alike in all their characters; let them state some difference between lead and iron, lead and silver, silver and gold, &c. And besides the difference in appearance, there is a very great difference in the results observed when various metals are exposed for some time to the air. Let them describe again how iron and lead change under such

circumstances, and how silver differs in this respect. Gold keeps its bright colour very well, so does tin; therefore, gold ornaments retain their original beautiful colour and appearance, while iron sheets are covered with tin to keep them from rusting.

[*Note.*—Mercury, if it has become dirty or dusty, may be cleaned and made bright most readily by folding a piece of writing paper into the form of a bag, making a number of holes in it with a pin, and letting the mercury run through these holes. Other metals should not be allowed to come in contact with the mercury.]

LESSON XIX.

REFLECTION OF LIGHT.

OBJECTS REQUIRED.—*Bright sheet of tin ('tinplate'); indiarubber ball; slate; sheet of smooth white paper; ordinary looking-glass. (If the sun is not shining directly into the room a gas flame or candle flame will be required.)*

ANALYSIS OF LESSON.

Recognise tin sheet as a metal,—characters of metals.
Difference between *shining* of metals and of sun, candle flame, &c.

Ex.—*Hold tin in bright light.*

Reflection of light falling on tin: proofs.

Ex.—*Lay tin in sunlight to give reflection on ceiling or wall.*
Hold hand between tin and patch of reflected light.
Move the tin and note movement of light.
Cover up tin with slate.
Remove tin, then replace it.

Source of the light and course.

Ex.—*Cut off light passing to tin by slate.*

Explain term 'reflection.'

Ex.—*Throw indiarubber ball against table or wall and note rebound.*

Different bodies vary in power of reflection—varying brightness.

Ex.—*Lay slate over (or in place of) tin reflecting light.*
Lay smooth white paper in same position.
Compare brightness of tin, paper, and slate.

Ordinary mirrors have metallic reflecting surface.

Ex.—*Repeat experiments with looking-glass in place of tin.*
Reflect light from window or candle on to child's face.

NOTES.

Subject of Lesson.—The bright, shining appearance of clean metals having been observed as one of their general distinguishing characters, in the present lesson it is shown that this brightness is due to their superior power of reflecting light; and several facts in connection with the general subject of reflection are discussed.

Show the children a clean and bright sheet of 'tin-plate,' and lead them by questions to name it, to describe it as a metal, and to state the general characters of metals.

Draw special attention to the bright lustre of the sheet; remind the children of the cleaning and polishing of metals until they are said to 'shine.' Let them name other bodies which are said to shine—e.g. the sun, a burning lamp, candle, &c. and point out that there is an important difference between the two cases, inasmuch as while the sunshine or a candle flame can light up an otherwise dark room, a bright sheet of metal cannot do this. Lead them to describe under what conditions the metal shines—viz. when placed in the light from the sun, candle, &c.—and hold the sheet in the bright sunlight or near a flame.

[If the sun does not shine brightly into the room, the room should be somewhat darkened, and the illustrations shown by means of the light from a gas flame or candle flame.]

Let the light fall on the metal sheet in such a way as to throw a bright patch of light on to the ceiling or a wall in view of the class. (Do not let the children call this patch of light a 'shadow.') Let them try and explain where the light comes from, and prove that it

passes from the tin to the ceiling or wall by (*a*) holding the hand in the course of the light so as to cast a shadow in the midst of the patch: (*b*) moving the tin and observing the movement of the light: (*c*) covering up the tin with a slate or duster so as to stop the reflected light: (*d*) removing the tin altogether.

But the light does not originate from the tin; let them describe its source, and trace its course. Cut off the light passing to the tin by a slate or other opaque object, and note the effect on the reflected light. Illustrate the passage of the light to the tin and its being thrown back by means of an indiarubber ball thrown in various directions against the surface of the table or the floor, and give the term 'reflected.'

Lay the sheet again in position to reflect the patch of light, and then cover it with a slate; ask the children to explain why the light disappears. Then lay a sheet of smooth and clean white paper on the slate; let the children observe that some of the light is restored, and lead them to the conclusion that some bodies reflect light better than others, and that those which reflect it best look bright to us. Note the dull, dark surface of the slate compared with the paper and the tin.

Repeat some of the previous experiments on reflection with an ordinary looking-glass, comparing its power of reflecting the light with that of the bodies previously tried. After letting the children state what class of bodies are good reflectors, explain that the looking-glass is composed of a sheet of glass with a layer of metal (chiefly mercury) behind it; so that in this case the good reflection is due to a metallic surface. Hold the mirror before them to let them note the bright appearance of the metal behind the glass, and explain that the images

of themselves and other objects seen in the mirror are also due to light reflected from the metallic surface. Prove the latter statement by reflecting the light from a candle or gas flame on to a child's face, and let him state what he sees on looking towards the mirror—viz. the image of the flame from which the light comes.

LESSON XX.

A BURNING CANDLE.

OBJECTS REQUIRED *Wax candle in candlestick; new candle, showing wick; matches; two slates; book; looking-glass; small piece of clean white string (or wool); blotting paper; sheet of glass. The room should be somewhat darkened.*

ANALYSIS OF LESSON.

Difference between bright candle flame and bright tin.

Part of candle giving light: proofs.

Ex. *Show candle unlit.*
Screen off flame only by two slates.

Light passes out in all directions; prove.

Ex. *Hold book in various positions about flame.*
Reflect light from mirror in various positions.
Hold hand or slate in various positions to cast shadow.
Make drawing of sun and flame, showing rays.

Heat is given out with the light in all directions.

Ex.—*Child hold hand in various positions near flame.*
Screen hand from flame by sheet of glass.

Name substance of candle; effect of heat.

Ex. *Child point out melted wax.*
Incline candle, and let melted wax fall on slate.

Melted wax rises up wick to the flame.

Ex.—*Hold end of white string in ink on slate.*
Hold blotting-paper in ink.
Hold string in melted wax of candle.

NOTES.

Subject of Lesson.—A burning candle is a source of light and heat, and it is so considered in this lesson, and certain phenomena connected with the burning of the candle are discussed.

Question the children as to the ordinary use of candles, and the conditions under which they are thus used. Contrast the bright candle flame with the bright metal surface considered in the last lesson, asking the children to describe clearly the difference between the two bodies.

The candle being said to give light, let the children state from which particular part the light really comes, and suggest some means of proving that their answer is correct e.g. if there is no flame, there is no light given out: if the flame only be screened off from view (as by holding two slates so as to prevent the flame from being seen while leaving the rest of the candle visible), the light is cut off. (For this experiment and some of the following ones it will be necessary to have the room somewhat darkened.)

Enquire next in which direction light passes from the candle flame; and prove that it passes out on all sides and in all directions, by showing that the page of a book is illuminated in various positions around and about a flame: by reflecting light from a mirror held in various positions about the flame: and by pointing out the shadows cast by a slate similarly held. Make a drawing to illustrate the usual manner of representing the sun or a candle flame, with radiating lines to illustrate the *rays* or lines of light passing out in all directions.

Let a child hold his hand near the side of the flame and describe that he feels heat coming to his hand.

Prove that it comes from the candle flame by interposing a slate or sheet of glass between the hand and the flame. Let the children state in what direction the heat passes from the flame, and describe how to prove their statement.

From what was learnt in a previous lesson they will be able to name the substance of which the candle is composed, and to state something then learnt as to the nature of the substance. Lead them especially to describe the melting of wax when heated, and to infer that if the heat of the candle passes downwards and falls on the wax it should be found to be melted. Let a child point out the melted wax; and, by holding the candle to one side, let a drop or two of melted wax fall on to a slate or piece of paper.

Then point out the wick standing in the melted wax, and describe it as a kind of string. (Show the wick in a new candle, and let some children ascertain by observation that it is composed of twisted or plaited threads.)

Put a small quantity of ink on a slate and hold in it the end of a piece of white string (not too thin nor too tightly twisted), and let the children describe what they observe, some of them being asked to stand near to the slate so as to see it more plainly. The ink will be seen to soak some distance up the string. Illustrate the effect more clearly by holding a narrow strip of blotting paper in the ink. Then hold another piece of string in the melted wax of the candle and point out a similar rise of the liquid up the string. Lead the children to infer from these observations that melted wax is constantly rising up the wick to be burnt in the flame.

This fact will explain why the candle as it burns gradually gets shorter, the wax burning away to produce the light and heat which have been observed constantly passing from it.

LESSON XXI.

SUNLIGHT AND THE SPECTRUM.

OBJECTS REQUIRED—*Burning candle (in candlestick); white card (or sheet of paper), set upright where sun can shine on it; thin sheets of coloured glass, or gelatine, of two or more colours; small slate; sheet of clear glass; glass prism (large one, say, 5 inches long by 1½ inch across, if possible), similar to those hung as 'lustres'; colour chart showing spectrum; sheet of cardboard (or brown paper) with narrow slit.*

[NOTE.—*This lesson must be given in a room into which the sun is shining.*]

ANALYSIS OF LESSON.

Questions on light and heat from candle.
Other sources of light.
Light (and heat) from sun compared with that from candle; effects.

Ex.—*Blow out candle; note no practical difference.*

'Transparent' and 'non-transparent' bodies; 'shadows.'

Ex.—*Place clear glass in path of light falling on screen. Use slate instead of glass; note shadow and explain.*

Some bodies transmit part of light and show colour.

Ex.—*Place coloured glass or gelatine in path of light. Repeat with different colour.*

Sunlight passing through prism forms 'spectrum.'

Ex.—*Hold prism in sunlight; note 'spectrum.' Move prism, remove it, cover it up, &c., and note effect.*

Principal colours of spectrum, and order; rainbow.

Ex.—*Examine spectrum on white screen or wall. Children look through prism at window, slit in card, &c. Examine colour chart of spectrum.*

Sunlight gives colours to flowers, &c.

NOTES.

Subject of Lesson.—The sunlight is much more powerful than the light from a candle, and the heat accompanying it is more readily observed although the sun itself is so distant. Some substances allow the light to pass through unaltered, others stop it altogether, while others, again, let it pass through, with the production of colour. The spectrum, or coloured band of light formed when sunlight passes through a glass prism, is examined, and found to consist of several colours in a regular and definite order. This observation of the spectrum will serve to lead up to the lessons on special colours immediately following.

Let the children point out the part of the burning candle which gives light; state in what direction the light passes, and with what it is accompanied.

Let them then name other sources of light—burning gas, lamps, the sun, &c.— and state which of these is best. Ask them whence comes the light which enables them to see the objects in the room. Blow out the candle, and let them note that there is no practical difference in the light, showing that the sun (although so distant) gives a very much stronger light than the candle.

Does heat come from the sun as well as light? Let the children answer this question, and give their reasons —e.g. they can feel the heat when the sun shines on them, bodies (especially black ones) are warmed by the sunshine, ice and snow are melted.

[The lesson must be given in a room into which the sun shines directly, and if a time can be chosen when the sun shines directly on to the space in front of the class where the teacher stands, that will be by far the most convenient arrangement.]

Direct attention to a place on which the sun is shining —e.g. a white wall, or a sheet of white cardboard or paper hung on the wall or blackboard, or supported on the table in an upright position, where the children can readily see it. Interpose a clean sheet of ordinary clear glass, and note that the light still passes through almost as well as before. Interpose a small slate instead of the glass, and let the children describe and explain the effect produced. Exercise them in the use of the terms 'shadow' and 'transparent.'

Then interpose in the path of the light a sheet of thin coloured glass (or gelatine); let the children say if the light passes through at all, and if any of it seems to have been stopped. As the patch of light is much less bright than before, they will understand that some of the light has been stopped, and will that see the part which gets through is coloured. Repeat the experiment with a sheet of some other colour.

Next let the sunlight fall on the side of a glass prism, held with its long edges horizontal, and with one of its long faces uppermost—thus: ▽ The prism may either be held in the hand or laid in the window where the sun can shine on it; and it must be turned about until the coloured band of light—the spectrum—is thrown on to the place (a white surface) where it can most readily be seen by the class. Show that the coloured band is really caused by the light passing through the prism: (1) by moving the prism about and noting the movement of the spectrum; (2) by removing the prism, and (3) by covering it up.

Let the children point out the colours readily observed in the spectrum, and note the order in which they occur —e.g. red, yellow, green, blue, with other colours and shades coming between. Ask which of them have seen

a similarly coloured band occasionally in the sky—the rainbow—and tell them to take the first opportunity of observing that the colours in it come also in the same order.

Several children might then be allowed to take the prism in their hands and look through it to the window, noting many coloured bands against the window bars, &c. If a narrow beam of bright sunlight can be obtained—e.g. through a partly-opened door, or between the side of a blind and the window, or through a narrow slit (say, about one-eighth of an inch wide) in a large sheet of brown paper or cardboard held in front of the window—a very good spectrum will be seen, especially if all adjacent light be carefully shut off. (The prism must be held with its long edges parallel to the slit, and it will be necessary to look not directly towards the light, but in an oblique direction, which will readily be ascertained by experiment.)

Refer to a colour chart showing the spectrum, pointing out the colours before observed and the intermediate shades.

Explain that this experiment shows that the sunlight really contains light of all these various colours; and that we can thus partly understand how it is that without sunlight leaves and flowers and other bodies grow pale and almost without any colour whatever, whereas in the sunlight we have formed all the many colours of flowers, &c., which we consider so beautiful.

[It would be well to place the prism in the window on several subsequent days to let the children become quite familiar with the beautiful colours of the spectrum produced.]

LESSON XXII.

RED.

OBJECTS REQUIRED—*Prism; burning candle (in candlestick); sheet of card or brown paper with narrow slit; sheet of white cardboard (or paper); red glass (or gelatine); matches; thin white tissue paper; disc of red paper; piece of red brick; red flowers (geranium, poppy, rose, &c.); red sealing-wax; mixed skeins of coloured wool; magenta dye; tumbler of water; empty tumbler; methylated spirit; glass rod; white wool.*

ANALYSIS OF LESSON.

Red always at one end of spectrum.

Ex.—*Throw spectrum from prism on wall or screen; let children look through prism at window, &c.*

Other means of obtaining red light; explain less brightness.

Ex.—*Let sunlight pass through red glass to screen.*
Hold red glass before window or candle flame.

Use of red light as signals, &c.

Examples of red objects—red hot wood; blood; bricks; flowers; sealing-wax &c.

Ex.—*Show glowing match; scorch paper with it.*
Place thin white tissue paper over red disc.
Show piece of red brick.
Show red flowers; compare together and with previous objects.
Show sealing-wax; compare with flowers, &c.

Some bodies give out red light, others only reflect it; **which?**

Bodies may be dyed red.

Ex.—*Select shades of red from mixed skeins.*
Dye white wool in magenta solution, stirring with glass rod.
Wash dyed wool in clean water.
Match red wools with other objects.

NOTES.

Subject of Lesson.—In this and the three succeeding lessons the principal colours of the spectrum are separately considered, and their relations to others pointed out. Common objects, having the particular colour under consideration, are brought together, and the great variety of different shades of colour thus illustrated.

By means of the prism throw the spectrum of sunlight on the ceiling or walls, as in the last lesson, and let the children point out the principal colours then observed. Let various children also look through the prism at the window, or a narrow beam of light, and note that there is always red light at one side of the band of colours. Tell them that in this lesson it is intended to speak only about this particular colour red.

Let the children explain some other means by which red light may be obtained—e.g. letting the sun or a lamp shine through red glass. Show them the patch of red light on the wall or sheet of white paper (or cardboard) formed when the light from the sun passes through red glass, and note that the light on the wall or paper is not so bright as when the glass is absent. Also hold the red glass between themselves and the window or the flame of a candle, and let them see the effect. Lead the children to explain this fact as due to the other parts of the light (let them name these other colours) being stopped, and only the red part being able to pass through. Ask them for examples of the use of red light obtained in this way—e.g. in signal lamps on railways, ships, tramcars, &c.

Next ask them to name various substances having a red colour—when possible show the object named, com-

pare it with the others to illustrate the difference in shade, and call attention to any fact of collateral interest in connection with the objects. The following examples should be among those referred to and illustrated :—

(1) Red-hot coal, iron, or wood. Blow out a burning match, and show the glowing end. Let the children state what the redness implies in this case—viz. great heat—and show how the red-hot body will scorch a piece of paper. Point out that while a kettle of boiling water is hot, it is not so hot as these red-hot bodies, and that the latter as they cool lose their red colour and become black.

(2) Blood. Point to the red lips as showing the colour of the blood shining through the thin skin. Lead the children to explain the pink colour of the skin and nails as due to the skin being thicker in those parts, so that the colour of the blood does not show so readily.

Illustrate this latter point by laying a sheet of thin white tissue paper over half of a bright red disc (either of red paper mounted on a sheet of white paper, or a red disc painted with crayon, water-colour, or bright red ink).

(3) Bricks. Note that all bricks are not red, and that there are various shades among red bricks. Let the children state the material from which bricks are made, and whether the unbaked clay is usually red; showing that the red colour is generally produced during the process of baking.

(4) Flowers. The rose, scarlet geranium, poppy, &c., might some or all be shown and compared with each other as to shade—referring to them as lighter and darker, &c.

(5) Sealing-wax. Compare it with the other objects named, and let the children select the flower, &c., most nearly like the wax in shade of colour.

Let the children state which of the red objects referred to above could be seen in a dark room; and lead them to explain that while the red-hot coal or wood gives out red light itself, the other objects do not themselves give out light, but must have light from some source falling upon them in order to be visible.

(6) Dyed wool. From a series of small skeins of wool of various colours [1] the children might be asked to select all those that might be spoken of as red. Let them state the natural colour of wool, and explain how the specimens shown have had their original colour changed.

Illustrate the process of dyeing by taking a small quantity of magenta dye (it can be bought in small penny packets), dissolving it in a tumbler containing a few drops of the methylated spirit used for the lamp, adding some water, and then stirring in the liquid some white woollen yarn. The yarn might afterwards be washed in a tumbler of clean water to show that the colour is 'fast.'

Some of the coloured wools should be matched with previous red objects by the children.

The red colour of the sky at sunrise or sunset, red sand or sandstone, red ink, and many other objects of similar colour might also be amongst those referred to by the children.

[1] Messrs. Philip, Son and Nephew, 51 South Castle Street, Liverpool, have arranged to supply a special series of coloured wools suitable for the illustrations mentioned in this and the following lessons.

LESSON XXIII.

YELLOW AND ORANGE.

OBJECTS REQUIRED—*Gold coin or ornament; piece of clean brass; leaves of Dutch metal; sulphur (roll brimstone); straw (with ear of corn attached if possible); lemon; orange; yellow flowers (buttercup, crocus, laburnum, &c.); chart of spectrum; four small saucers for water-colours; gamboge and carmine colours; tumbler of water; two broad camel's-hair brushes; white cardboard (or drawing block); skeins of wool of various shades of red, yellow, and orange. [Series showing painted bands graduating from yellow through orange to red.]*

ANALYSIS OF LESSON.

Name principal colours of spectrum in order.
Various yellow objects.

Ex.—*Children point out yellow objects on table, and name.*

(*a*) Gold; ornamental; not tarnish; some uses.
(*b*) Brass; metal (*give proofs*); soon tarnishes.
Dutch metal leaves.
(*c*) Sulphur.
(*d*) Straw; bleaching.
(*e*) Lemon.

Name various tints of yellow after objects.

(*f*) Flowers; compare with previous objects.

Orange comes between red and yellow.

Ex.—*Compare orange with lemon.*
Point out orange on chart of spectrum.

Orange tint produced by mixture of red and yellow.

Ex.—*Paint stripe of yellow; when dry, paint overlapping red stripe.*

Various intermediate tints.

Ex.—*Paint yellow stripe and red stripe at distance, and fill up with yellow mixed with more and more carmine, and carmine with more and more yellow.*
Show previously prepared graded series of tints.
Arrange coloured skeins in similar order.
Match previous objects with wools and painted stripes.

NOTES.

Subject of Lesson.—Examination of objects showing various shades of yellow, and the illustration of the passage from yellow to red through the intermediate orange.

Ask the children to name, in proper order, the principal colours observed in the spectrum of sunlight. State that it is the object of the present lesson in the first place to consider that colour known as yellow, and let several children select from the objects on the table those which they would describe as having that particular colour.

Then let them state, as far as possible, what the objects or substances are; and question them very briefly as to the nature and use of each, so far as to make sure that they distinctly recognise it. Lead them, at the same time, to compare the shade of colour of one object with that of another; and dwell particularly on any use of the substance connected with its colour. The following notes will suggest certain points that might be brought out:

(1) Gold. Ask them to state some facts about gold learnt in a previous lesson, and mention some of its uses, leading them to explain its employment for ornamental purposes as due in great part to its beautiful colour, which does not readily tarnish. Refer also to its use for covering picture-frames, edges of books, letters on books and signboards, &c.

(2) Brass. Lead them to speak of it as a metal—giving reasons for so doing—and to mention some of its uses. Compare its colour with that of gold, and refer to the necessity of frequently cleaning brass in order to preserve its bright yellow appearance.

A leaf of Dutch metal (often used as a substitute for

gold leaf, and readily obtainable from a paint shop), might be shown as a specimen of brass rolled out into a very thin sheet.

(3) Sulphur (brimstone). Not a metal, and has not the bright appearance so characteristic of metals.

(4) Straw (unbleached). This might be shown with the ear of corn attached. (The bleaching—or whitening—of the straw might be briefly mentioned, a specimen of bleached straw being shown for comparison.)

(5) Lemon. Compare with the colour of previous objects, and lead the children to enumerate the various shades observed as golden yellow, brass yellow, sulphur yellow, straw colour, lemon yellow.

(6) One or more flowers (e.g. tulip, crocus, buttercup, wallflower, laburnum, dandelion, daisy) should be shown, either in a fresh state or dried and mounted, and their colour compared with that of the other objects.

(7) Orange. Lay the orange side by side with the lemon, and let the children note the difference in colour. Show on the chart of the spectrum that between yellow and red comes an intermediate tint known as orange.

To illustrate the relation between red, yellow, and orange, mix some gamboge water-colour (by preference use the moist water-colours sold in tubes) in one small saucer and some carmine in another. With a broad camel's-hair brush paint on a piece of white cardboard or a drawing block a broad stripe (say one inch wide) of yellow, and let it dry. (While it is drying the colour of some of the objects before seen might be compared with that of the painted band.) Then with another brush paint a similar stripe of red (carmine) by the side of the yellow in such a way that half the red stripe overlaps half the yellow. Let the children note the relation

between the simple red, the simple yellow, and the orange tint due to the mixed colours.

Paint a broad stripe of red, and at a distance of three or four inches a parallel stripe of yellow. Then add a very little of the carmine to the yellow—this is best done in a separate saucer—and paint a stripe next the yellow; add a little more carmine and paint another stripe, and continue adding more and more carmine and painting stripes till a full orange is obtained. Then commence near the carmine stripe and paint another with carmine to which a little yellow has been added, and so on, adding more and more yellow till full orange is again reached. [A good series of painted stripes illustrating this gradual shading from yellow to red should be previously prepared, and a similar series might also be made with each shade on a separate piece of cardboard. In the latter case it would be a good exercise for the children to lay the series of coloured strips in proper order.]

A series of several small skeins of coloured wools, including a bright red, a bright yellow, and several intermediate shades, might be given to the children to arrange in proper order and to be compared with the various painted stripes.

LESSON XXIV.

BLUE.

OBJECTS REQUIRED—*Prism; chart of spectrum; cobalt blue and carmine water-colours; four small saucers or dishes for paints; two broad camel's-hair brushes; white card-board (or drawing block); skeins of various coloured wool, including several shades of blue; washing blue; three tumblers of water; glass rod; white wool; blue glass (or gelatine); ruled foolscap paper; blue pencil. [Series of painted strips graduating from blue through purple to red.]*

ANALYSIS OF LESSON.

Relation between red, yellow, and orange.

Ex.—*Show spectrum, and point out red and yellow.*
Show orange on chart of spectrum.
Point out blue, and note change in both directions.

Mixtures of blue and red—violet, purple, crimson, &c.

Ex.—*Paint stripe of blue; successive stripes of blue with more and more carmine added.*
Paint (leaving an interval) stripe of carmine, and successive stripes of carmine with more and more blue added.
Show series of stripes illustrating passage from blue to red.

Blue in light and dark shades.

Ex.—*Children select blue skeins from bundle and arrange in order.*
Compare wool with painted stripes.
Compare washing blue with wools.
Add washing blue to water, stir white wool in it; afterwards rinse in clean water.

Natural blue objects—flowers, sky, sea.

Ex.—*Show blue flowers, blue sky through window or in picture.*

Note blue lines on paper, blue pencil, &c.

Blue glass stops much light.

Ex.—*Hold blue glass before window; let light shine through it on to paper.*

NOTES.

Subject of Lesson.—Blue is the colour to be considered in this lesson, and the tints of purple, violet, &c., produced by the mixture of blue and red.

Let the children see the spectrum of sunlight again, and point out the colours already considered—viz. red and yellow. On a coloured diagram of the spectrum point out the same colours, and refer to the intermediate tints of orange which are well seen when a very broad spectrum is obtained by means of special prisms.

Then direct attention to the colour at the other end of the spectrum—viz. the blue—and point out how in one direction it shades into the green (to be considered in the next lesson), and in the other it gradually fades away, passing through various shades of blue. [The full blue of the spectrum can only be seen properly by cutting off as much light as possible except that passing through the prism, as, for example, by admitting a small beam of light through a narrow slit into an otherwise darkened room.]

Mix some blue water-colour (cobalt blue), and with it paint a broad stripe on a piece of cardboard or a drawing block. Put some of the blue colour into another saucer, and add to it by means of a separate brush a very little carmine ready mixed with water; paint a stripe of this mixed colour by the side of the other, letting the children note the difference of tint. Paint two or three other stripes, each time adding more carmine. Leave sufficient space and paint a stripe of simple carmine, and then in the space several other stripes after the addi-

tion to the carmine of more and more blue; point out the gradual passage from one colour to the other, and tinguish good illustrations of violet and purple. [A ed series of these should be previously prepared.]

Get a series of coloured wools containing several shades of blue; let the children select all the specimens which might be included under the general term blue, and compare them with the various painted tints, and also arrange several in order from the lightest shade to the darkest.

A specimen of the blue cakes used in connection with washing might be shown, and similarly compared with the wools and the painted strips. Some of the blue might be broken into a tumbler of water and stirred up well, and a piece of white wool dipped into it. This might afterwards be washed in a glass of clean water to show that the colour in this case is not 'fast.'

Let the children name any blue objects they remember. Lead them to speak of certain blue flowers (hyacinths, bluebells, violets, &c.), showing examples of some of these if possible.

The blue sky should be referred to, and, if possible, pointed out; and the children should be asked to state under what conditions the blue sky is seen, and whether they would describe it as light blue or dark blue. The children might also have heard or read of the blue sea, and perhaps some coloured picture might be found showing the sea and sky so coloured.

The faint blue lines so often ruled on exercise books or foolscap paper should be noted, and a blue pencil and blue or violet ink might also be used to illustrate the use of this colour.

Some blue glass might be held up in front of the

window, or the light passing through it allowed to fall on a white sheet of paper, and children might be allowed to look at objects through it. Lead them to observe that in all these cases much of the light is stopped, and everything looks comparatively dark.

LESSON XXV.

GREEN.

OBJECTS REQUIRED—*Prism, or chart of spectrum; mixed coloured wools, containing various blues, yellows, and greens; water-colours (gamboge yellow and cobalt blue); four small saucers for paints, two broad camel's-hair brushes; tumbler of water; white cardboard (or drawing block); various leaves (including holly, and some showing autumnal colours); orange, lemon, or apple, partly green; brass or copper with verdigris; green glass (or gelatine).*

ANALYSIS OF LESSON.

Colours of spectrum in order; position of green and orange.

Ex.—*Show spectrum again or use chart.*

Relation of green to blue and yellow.

Ex.—*Select blues, yellows, and greens from mixed wools, and arrange in order.*

Paint broad stripe of blue, and, when dry, overlapping yellow stripe.

Paint series of stripes from yellow through green to blue.

Blue-greens and yellow-greens.

Ex.—*Illustrate by wools and painted stripes.*

Natural green objects.

(*a*) Leaves—evergreen; autumnal.

Ex.—*Compare various leaves, under and upper surfaces. Show autumn leaves.*

(*b*) Fruit—ripening.

Ex.—*Show apple, orange, &c., partly changed from*

nature.

—*Show brass or copper with verdigris.*

Green glass—signals.

Ex.—*Hold green glass before window; let light through it fall on paper.*

NOTES.

Subject of Lesson.—Various shades of green and the relation between green, blue, and yellow are studied.

Let the children name, in order, the chief colours of the spectrum, and remind them of the observation in the last lesson of blue gradually passing into green. Ask them to say what two colours green comes between; and remind them of what was previously learnt about orange standing between red and yellow, and about the production of orange colour by the mixture of paints of those two colours.

From a series of coloured wools let them select all those called blue, then all those called yellow, and then all called green. Lay the green ones between the blue and yellow, and note that there are various shades of green.

Prepare some yellow (gamboge) colour in one saucer, and some blue (cobalt) in another. Paint a broad stripe of yellow, and when it is dry paint by the side of it, and partly overlapping, a similar stripe of blue. Let the children name the three coloured stripes thus formed, and explain the green as due to the mixed blue and yellow.

Then paint a series of stripes illustrating the gradual passage from blue to yellow through various greens, commencing at one end with pure yellow, and adding more and more blue till a full green is produced; then commencing again at the other end with pure blue, and gradually adding yellow. Let the children point out all the stripes which they would describe as green, and lead them to distinguish some as bluish greens and others as yellowish greens.

Ask the children to mention common objects having a green colour:—

(1) Leaves of trees, grass, &c. Show several varieties of these, and let the children observe the variation in shade, both on the upper and under surfaces and in leaves from various trees. Let them name some green leaves eaten as food, and describe the changes which usually take place in the colour of leaves in autumn before they fall off. The fact that certain trees always remain green, and the name given to such trees ever-green—should be drawn from them, and examples of evergreen trees (e.g. holly) given.

(2) Fruit. Let them mention the names of various green fruits, and in the case of some of these it will be easy to illustrate the fact that many green fruits change colour as they ripen. Ask them to describe what other change takes place (e.g. in taste) as fruits ripen. [Oranges or lemons can often be obtained partly green.]

(3) The green substance (verdigris) formed on copper or brass when certain substances (e.g. grease) are allowed to remain for some time in contact with those metals might be mentioned, and illustrated if possible. (Some lard or butter might be put on a penny or a piece of brass a day or two before the lesson, and allowed to remain till the lesson was given.) Its *very* poisonous nature should be referred to, as also the fact that many varieties of green paints are more or less poisonous.

(4) Green glass, held before the window, should be shown, and the children led to speak of its use in lamps for signals on railways, &c.

LESSON XXVI.

BLACK AND WHITE.

OBJECTS REQUIRED—*Sheet of note paper; foolscap paper; leaf of exercise book; chalk; milk (in clear glass); bleached and unbleached calico; glass of water; bright silver coin; white cardboard; black paper (dull black); book; ink, broad pen, and ruler; lead pencil.*

ANALYSIS OF LESSON.

Examples of coloured bodies.
Name white bodies—paper, milk, snow, &c.
  Ex.—*Compare chalk, &c., with water, if necessary.*
'White' bodies often tinted.
  Ex.—*Compare various sheets of paper.*
    Compare chalk and white paper with milk—'cream colour.'
    Compare silver coin in good light with white paper—'silvery white.'
Bleaching of natural bodies—calico, straw, &c.
  Ex.—*Compare bleached and unbleached calico.*
Bodies excluded from light are black—night: shadows.
  Ex.—*Cast shadow on white paper; describe colour.*
White bodies reflect light.
  Ex.—*Hold open book with back to light; then reflect light by cardboard on to page; repeat several times.*
Black bodies cannot reflect light.
  Ex.—*Repeat last experiment with dull black paper over cardboard.*
Black and white clouds; explain.
Enumerate black substances.
Black on white and white on black—ink, chalk, &c.
Grey as mixture of black and white.
  Ex.—*Rule broad ink and lead pencil lines near together. Rub chalk powder on blackboard.*

NOTES.

Subject of Lesson.—Having taken up in the preceding lessons the principal colours of the spectrum, it is desirable before revising the subject of colour generally to consider black and white, their relation to each other, and various natural examples of each. Grey as an intermediate shade is also briefly considered.

Let the children name various colours, and give examples of bodies possessing each colour named.

Show them a piece of white paper; let them state its colour and give other examples of white bodies—e.g. milk, snow, wool, calico, chalk. Do not let them speak of water and ordinary glass as being white; if they do, set the water and a sheet of white paper side by side and let them see the difference. [Water and other colourless substances will be referred to in the next lesson.]

Ask them to state several purposes for which white paper is ordinarily used. Get several specimens of paper used for writing—e.g. piece of note paper, foolscap paper, leaf from an exercise book—and compare them with each other and with chalk. Let the children state whether all are exactly alike; if not, let them point out those which they would regard as white, and give some description of the others, stating with what colour each is tinged. Compare, in a similar way, some milk in a (colourless) glass or bottle with the white paper and the chalk, and note its yellow tinge. Explain the term 'cream colour.' [These comparisons should be made in a good light.]

Hold a clean and bright silver coin (a florin or half-crown) in a good light, and place by the side of it a sheet of white paper; let the children give their statements

as to the colour of the silver, and thus illustrate the use of the term 'silvery white.'

Show them bleached and unbleached calico, and explain the use of the term 'bleaching' as meaning to make white. Refer again to the bleaching of straw.

Place a sheet of paper or cardboard in sunlight, and cast a shadow on it by means of the hand or a book held near the sheet. Let the children observe the shadow, describe it (stating its colour), and explain the manner in which it is formed. Point out that the paper, where the shadow falls, is black because the light is prevented from getting to it, and refer to the black colour of all objects at night or in a dark room. For the same reason, snow, chalk, &c., are black when a shadow is cast on them.

Let a child stand with his back to the window, holding in front of him an open book or reading card also turned away from the light. After calling attention to the poor light falling on the card, and the comparative difficulty of reading it, hold a large sheet of white paper or cardboard in the sunlight some little distance in front, and slightly inclined so as to reflect the light back on to the book or printed card. Repeat this several times, and lead the children to describe and explain the effects observed.

Then take a sheet of black paper (dead black surface paper, not bright or glazed black), and show that it does not throw back the light as the white paper did. (Hold the cardboard so as to reflect the light, then place over it the black paper). Lead the children to state, as the result of these observations, that bodies are black because either they have no light falling on them, or they do not throw back to us the light which does fall on them.

Refer the children to the white clouds often seen in

the sky, and let them state the colour of the clouds when they are in front of the sun and hide it from us. Lead them to explain the black or dark colour in this latter case.

Ask them to name other black substances—e.g. coal, soot, ink, &c.—and distinguish between those which are bright black and those which are dull (or dead) black.

Refer to the fact that black ink is used to write on white paper, and let the children give a reason for that fact. Let them also state why white chalk or paint would be unsuitable for writing on white paper, and say under what circumstances such substances would be the most suitable—e.g. on the blackboard or on dark coloured paper.

Lastly, rule a broad line with black ink on a sheet of white paper, and by the side of it a thick line (or several lines) with a lead pencil. Let the children compare the two marks, and note that the pencil line cannot be properly described as black in the same sense as the ink line. Speak of it as 'grey,' and show another illustration of grey by rubbing a thin coating of chalk powder on the blackboard with the finger. In the latter case it is plain that the 'grey' is due to the combined effect of the black and the white surfaces, and grey may be considered in many cases as a mixture of black and white particles.

LESSON XXVII.

COLOUR.

OBJECTS REQUIRED—*Prism; gamboge yellow, carmine red, and cobalt blue water-colours; three small saucers; three broad brushes; white cardboard (or drawing block); series of various coloured wools; two glasses of water; glycerine (in colourless [illegible]*

ANALYSIS OF LESSON.

Sources of light; light-giving and non-light-giving bodies.

Colours of objects named—in daylight—at night.

Production of spectrum; order of colours,—rainbow.

Effects of mixing certain colours.

Ex.—*Paint parallel stripes of red, yellow, and blue. Paint overlapping stripes of same.*

Gradation of colours in spectrum.

Arrangement of coloured objects—wools.

Ex.—*Select skeins of wool and lay in order of spectrum. Select colours intermediate between two given.*

Tints and shades of one colour.

Ex.—*Select series showing blue passing into black on white.*

Examples of natural objects of colour named; advantage of variety of colour.

Colourless bodies—water, glycerine, ice, &c.

Ex.—*Compare water, glass, &c., with paper and coloured objects.*

Light reflected from surface of colourless bodies—images in water.

Ex.—*Set glass of water in sunlight; note reflection.*

NOTES.

Subject of Lesson.—This lesson is intended mainly for the purpose of revising the principal facts learned in the previous lessons on colour, especially as regards the order and relationship of the various colours. Examples of colour in bodies are mentioned, and the fact pointed out that certain bodies are entirely devoid of colour.

Commence the lesson by asking the children to name various sources of light; let them distinguish between bodies which shine by their own light and others which are invisible except when light from some other source falls on them. Ask them to describe the direction in which light passes from the sun or a candle flame; and again illustrate by a diagram the manner in which rays of light are represented as passing out in all directions.

Then let the children state the colour of various natural objects named by the teacher e.g. grass, a rose, milk, the sky, soot, gold, &c. and remind them of what was said as to the colour of these objects at night or in a dark room. Let them explain what is meant by 'daylight'; and explain that in such light we see the proper colour of objects.

Ask them next to describe the means by which, in previous lessons, sunlight was broken up into several colours; and let them name the principal colours of the spectrum in order. Show them the spectrum again, and let them state where they may sometimes see a band of similar colours similarly arranged—viz. in the rainbow.

Prepare some red, yellow, and blue paints, and paint three parallel stripes of colour near but not quite touching each other. Question the children to see if they

remember the result of mixing the various colours together. Then paint a broad stripe of red, and when that is dry a stripe of yellow partly overlapping the red, and then, again, a stripe of blue partly overlapping the yellow. Lead them to observe the difference between such a series, where the change from one colour to another is abrupt, and the spectrum, where one colour gradually changes into another.

Exercise them with a set of dyed wools in choosing and laying a series in the order of the spectrum; in selecting a series which fills in some of the intermediate steps between two colours given to them—e.g. yellow and blue, green and blue, orange-red and bright yellow, &c. Also let them arrange a short series of shades of one colour (blue, for example) illustrating the passage, on the one hand, through lighter tints into white, and, on the other hand, through darker shades into black.

Ask them to give examples of bodies having particular colours named: leading them to name, by preference, flowers, fruit, animals, or other natural objects. Point out to them how much more beautiful it is to see this variety of colour in nature—the blue sky, the green grass, the many-coloured flowers, birds, butterflies, &c. —than if all were of one uniform tint. [This variety of colour might be illustrated by means of some coloured picture of a landscape, or of animal or vegetable life.]

Show the children a glass of water, and let them say how they would describe the colour of the water, helping them by such questions as—Is it red? green? white? &c. Compare it, if necessary, with chalk, paper, or other objects to show it cannot properly be described as having any colour, and explain the term *colourless*. Let them give other examples of colourless bodies—e.g.

the glass vessel containing the water, glycerine, clear ice, &c.

Point out that the surface of the water and of the glass vessel looks very bright, especially as seen from certain positions; lead the children to connect this brightness with the brightness of clean metallic surfaces, and to regard it as due to the same cause - the reflection of the light. If the water be set in the path of a beam of sunlight, so that the light falls on the surface of the water, a bright reflection will be seen on the wall or ceiling, which moves about as the water is disturbed. Remind the children that on looking into lakes or ponds the reflected images of surrounding objects are often seen; and the water may look blue owing to reflecting the blue of the sky, and is often so painted in pictures.

LESSON XXVIII.

A PAIR OF TONGS.

OBJECTS REQUIRED—*Poker ; pair of (clean) fire-tongs ; pencil ; small piece of coal ; two narrow strips of paper (say, 8 inches by 1 inch) ; pin.*

ANALYSIS OF LESSON.

Questions on poker—use, material, &c.

Name other 'fire irons'; use of tongs.

Methods of taking up coal—advantage of tongs.

Method of holding body between fingers—advantage of finger and thumb.

Ex.—*Child pick up chalk and hold between different fingers.*

Body held must be pressed.

Ex.—*Let pencil slip through fingers ; then hold tightly.*

Tongs similar to fingers—flattened ends ; pressure.

Ex.—*Child lift and hold coal by tongs.*

Movement of arms of tongs ; joint.

Ex.—*Children imitate movement with fingers.*

Pin two strips of paper at one end to board ; open and close.

Point out joint and pin in tongs.

Name other instruments of similar construction.

Material of tongs—advantage of iron.

Tongs require to be moved—arrangements for easy handling and movement.

Best position for laying tongs.

Ex.—*Children lay tongs in several positions and say which best.*

NOTES.

Subject of Lesson.— A pair of ordinary fire-tongs furnishes a simple object of study, the structure and manner of use of which the children can readily understand, while they can easily be led to perceive the necessity for some such instrument and its adaptability to its special purpose.

Remind the children of a previous lesson on the poker, and question them as to the use of that instrument, the material of which it is composed, and the special advantages of that material for the purpose. Then let them give the names of other instruments used in connection with an ordinary house fire—tongs, shovel, &c. Let them specially describe the use of the tongs, and the manner in which they are used.

Lead the children to describe several ways of picking up a piece of coal, and to explain the advantage of taking it up with the tongs rather than with the fingers—especially when the piece of coal is for some reason or other to be taken off the fire.

Direct attention to the manner in which things are held between the fingers; let them state which fingers are best for the purpose, and try to hold a piece of chalk or small stone between different pairs of fingers, and then between the thumb and first finger. Briefly explain why this latter arrangement is best—viz. because the thumb can be bent round so that the broad front surfaces can be pressed towards each other. Let them also note that an object to be held must be more or less pressed between the fingers, showing by means of a piece of chalk or a smooth pencil that if loosely held it is liable to slip out.

Ask some child to take up a piece of stone or chalk

with the tongs and to hold it in view of the class. Let the children note that the tongs hold the substance like the finger and thumb might do, and that the two parts or arms of the tongs have to be pressed together—ask them to give the reason for this. Let them also explain why the ends of the tongs are flattened, and why they are usually black at that part.

Show that the two parts can be moved from or towards each other; ask them how they would describe such movements—opening and closing the tongs—and let the children perform similar movements with their thumbs and fingers. Let them also try to ascertain and describe how the two parts of the tongs are joined together so as to be able to move. Illustrate this by taking two narrow strips of paper laid on each other, putting a pin through one end, and sticking it into the blackboard or easel; then open and close the strips like a pair of tongs. Ask them to name other instruments which are made of two parts fastened together in a similar way so that they can be moved (scissors, &c.).

The material of which the tongs are made should be the next subject of conversation; the advantages of iron for the particular purpose its strength, difficulty of melting, &c. being suggested by the children. They should also be led to describe iron as a metal, and the manner in which, and the conditions under which, it sometimes rusts.

It might then be pointed out that the tongs cannot move themselves; they have not power to move as most living things have. Let the children describe what is done to make it pleasant and easy for us to hold and to move the tongs—viz. they are made round and smooth and clean, and, if necessary, are oiled at the joint.

If there is time attention might be directed to the fact that the tongs lie on the table in one position much more steadily than in any other; let the children find out by trial which is the best position, and then explain the reason.

LESSON XXIX.

A PAIR OF COMPASSES.

OBJECTS REQUIRED.—*Ordinary drawing compasses ('**dividers**'); compasses for blackboard (or large-sized compasses with lead pencil and sheet of cardboard); tongs; drawing pin; string (twelve inches long, with loop at each end); chalk; rule; small rounded stone.*

ANALYSIS OF LESSON.

Comparison of tongs and compasses.

Ex.—*Pick up small stone with tongs and compasses.*

Differences between tongs and compasses—e.g. stiffness, and its advantage.

Ex.—*Hold open compasses in various ways.*

Angles of various sizes.

Ex.—*Illustrate angles by compasses, and draw on board.*

Marking series of points at fixed distances.

Ex.—*Open compasses four inches, mark series of points in line.*

Child try to do same with tongs.

Marking series round centre—advantage of pointed end.

Ex.—*Let child open compasses five inches: mark points round centre.*

Circle—circumference, centre; diameters (equal).

Ex.—*Fill in more points between those last made.*

Describe complete circle on board.

Rule several diameters—measure.

Children draw circles of given radius.

Describing circle by means of string—principle.

Ex.—*Describe circle with string, drawing pin, and chalk.*

Double string and let child describe circle.

NOTES.

Subject of Lesson.—A pair of ordinary drawing compasses is very similar in construction to the tongs examined in the last lesson; but certain differences in detail will readily be understood by the children to be necessary on account of the different purpose to which the instrument is put. The examination of the compasses leads naturally to a short consideration of the general properties of the circle.

Let the children themselves suggest what other instrument the compasses are like, and point out the resemblance. Let them also state the use of the tongs, and say whether the compasses would be suitable for the same purpose. Try to pick up a rounded stone or marble with the compasses, and let the children explain why this could be done much more readily with the tongs.

Then let them describe any differences they observe between the two instruments; and suggest to them that perhaps they may be able to find out reasons for these differences.

Lead them to observe as one point of difference the greater difficulty with which the legs of the compasses are opened and closed, and let them explain why this would be a disadvantage in the case of the tongs. Point out that on account of this stiffness the legs of the compasses remain open to any extent; and show that they may be laid down and taken up again, and held by the top or either leg without change in the relative position of the legs.

Speak of the space between the legs as an *angle*; draw two lines on the board enclosing an angle, and by opening the legs to various distances illustrate angles of different sizes.

Open the compasses so that the points are four inches apart as measured by a rule. Mark any point on the blackboard; then with the compasses find another point four inches from the first, and mark it; mark a third point at the same distance from the second, and so on with a series of points. Then let the children state whether there was in that case any advantage in the legs moving stiffly, and also in the legs being pointed. Let them compare the performance of such an operation with an ordinary pair of tongs instead of with compasses.

Let a child open out the compasses to a distance of five inches. Make a mark near the centre of the board and put one point of the compasses there; then, keeping that point fixed, mark a series of several points round the first at distances of five inches from it (so as to get a number of points on the circumference of a circle). Let the children state in what respect all these latter points agree; and explain the advantage of having the leg standing in the centre coming to a sharp point - viz. to prevent it from readily slipping out of place.

Fill up the spaces between the marks with others, until the outline of a circle is distinctly indicated. Then with a pair of compasses holding a pencil or piece of chalk describe a complete circle, and point out that the curved line (called the *circumference*) is everywhere at the same distance from the *centre*. Draw several lines from the centre to the circumference, and show that they agree with the extent of opening between the points of the compasses. Let the children again describe the advantage of having the compasses made to work stiffly.

Let several children draw circles of varying size by means of the compasses. In one circle draw three ***diameters***; help the children to describe the lines as

passing from the circumference on one side through the centre to the circumference on the other side, and question them to see if they understand that all such lines are equal in length. Let some child prove this by measurement.

Fix a drawing pin in the board, and taking a piece of string about six inches long, with a loop at each end, place one loop over the pin, and with a pencil or chalk in the other loop describe a circle. Let the children name the figure drawn, point out the centre and circumference, and explain how they know it to be a circle and also explain the use of the string.

Put both loops over the pin, and let a child describe a circle by means of the string so placed.

LESSON XXX.

THE PENDULUM.

OBJECTS REQUIRED—*Lead bullet (key, or other small heavy body) hung from long thin string about thirty-six inches long ; drawing pin ; sheet of paper.*

ANALYSIS OF LESSON.

Description of circle—centre, circumference.

Ex.—*Describe arc of circle on board by chalk in string over pin.*

Position of weighted string at rest ; motion after displacement.

Ex.—*Hang weighted string from pin on vertical board and mark line of string at rest.*

Draw weight to one side ; let them state effect, then release.

Path of swinging body.

Ex. *Child draw path on board ; then trace by means of string.*

Cause of stopping.

Ex.—*Let pendulum swing against board till it stops.*

Suspend pendulum to swing freely.

Pendulum in clock—cause of 'ticking' and continued motion.

Regularity of oscillation.

Ex.—*Beat time along with pendulum—count twenty with it.*

Repeat same looking away part of the time.

Shorter pendulum swings quicker.

Ex.—*Shorten pendulum ; beat time, and count with and without looking.*

Shorten again and repeat exercises.

Application of pendulum to measuring time—regulating clock.

Heavy body required for pendulum ; why ?

Ex.—*Tie sheet of paper to string and set swinging.*

NOTES.

Subject of Lesson.—The motion of the pendulum in a circular arc is directly connected with the describing of a circle by aid of a piece of string as considered in the last lesson. The regularity of movement and the dependence of the rate on the length of the pendulum are readily observed. The lesson also affords a good opportunity of practising the children in estimating successive equal intervals of time.

[illegible] fastened to a drawing pin, as in the last lesson, draw part of a circle on the blackboard; let the children name the figure being described, point out the circumference and the centre, and state the use of the string.

Then, placing the blackboard as nearly vertical as possible, hang a small heavy body (such as a lead bullet, metal button, or key) by means of a long thin string from a drawing pin fixed near the top of the board. Mark with chalk the (vertical) line which the string traces out when the body hangs at rest. Draw the body to one side, and let the children state what will happen when you release it and in which direction it will move. Let it swing once; then draw it again to one side, and let some child try to mark with chalk on the board the line along which the body moved. Let it swing again several times, and then let a child hold a piece of chalk against the body and move it with the body to trace out the path. Let the children state what curve it is, and how they know it is part of a circle.

Let the body swing several times till it stops, and ask the children to explain why it stops so soon—viz. it is stopped by rubbing against the board.

Then suspend it by a string about thirty-six inches

long from the gas pendant, or in some other place where it can swing freely; set it swinging, and after noting that it does not now stop so soon, let the children give the reason.

Many of them will have seen something swinging like this before, let them state where—in the clock—and give its name—the *pendulum*. Point out the pendulum in the school clock if it is visible. Then draw from them that there is one difference, in that the pendulum in the clock makes a noise as it swings (let them give the name 'ticking'), and explain that this noise is caused by something in the clock which gives the pendulum a push every time it swings. Lead the children to understand that this is the reason why the pendulum in the clock swings for a very long time without stopping.

Let the children with their hands beat time with the swinging pendulum. Also let them count up to twenty with the swings; and then let some child, with his eyes shut or back turned, try to count with the pendulum after the teacher has counted (say) five with him. Point out how regularly it swings, always keeping the same time.

Then shorten the string about six inches, and repeat the same exercises, letting the children describe in what respect the motion differs from that in the first instance. Again shorten the string (to about twenty inches), and repeat the exercises, and lead the children to state the general rule that a shorter pendulum swings quicker than a longer one.

Tell them that it was because people noticed how regularly the pendulum swings backwards and forwards that they thought of using it for clocks to measure time; and let them state what alteration could be made in a clock that went too slowly—viz. the pendulum might be made shorter.

Tie a sheet of paper to a string, hang it up and use as a pendulum. Ask the children to state what they observe, and lead them to describe the air as interfering very much with the motion of the paper (as explained in a former lesson), and to understand the necessity for having a small but heavy body at the end of the pendulum.

LESSON XXXI.

VERTICAL, HORIZONTAL, AND INCLINED.

OBJECTS REQUIRED *String with weight (as for pendulum); drawing pin; pointer; new lead pencil; slate; several books (ten or twelve); water in flat-sided bottle (or tumbler); large-sized marble (or hard ball).*

ANALYSIS OF LESSON.

Questions on pendulum position at rest.

Ex.—*Hang pendulum on board, swing, and mark line when at rest. Repeat several times.*
Suspend pendulum freely, and note position of rest.
Children hold pointer and fingers in same position.
Set pencil in same position on table—to stand alone.

Name position—*vertical* 'upright.'

Ex.—*Child stand upright.*

Examples of bodies standing vertical; 'plumb line.'

Ex.—*Test walls, board, door, &c., with weighted string.*

Advantage of building vertically.

Ex.—*Build pile of books vertical, then each projecting.*

Horizontal or 'level' relation to vertical.

Ex.—*Note direction of surface of water.*
Child hold pointer, slate, &c., horizontal.
Draw horizontal line on board across vertical; note equal angles.

Liquids characterised by horizontal surfaces.

Bodies on horizontal, vertical, and inclined surfaces—floor, walls, hills, &c.

Ex. *Lay marble on horizontal slate; then incline.*
Lay marble on table; incline.
Draw line on board inclined to horizontal line, and give name.
Rest book on inclined slate; then incline slate till book slides.
Point to maps, &c., on walls.

NOTES.

Subject of Lesson.—The pendulum at rest gives a vertical line; and this direction, which is one of great practical importance, may best be found by a 'plumb line' similar in construction to the pendulum used in the last lesson. The horizontal direction—best shown by the surface of liquids at rest—is at right angles to the vertical at any place. A line in any other position may be described as inclined or slanting.

Suspend a small heavy body by string (in front of the board set vertically) for a pendulum, as in the last lesson; set it swinging, and while it is coming to rest ask the children some simple questions as to the facts observed in that lesson. When the body is at rest carefully mark with chalk the line traced out on the board by the string. Set the pendulum swinging again several times, and let it come to rest, noting that each time when at rest it hangs in the same position.

Then suspend the pendulum from the gas pendant or other support away from the wall or board, and note the position it takes up when at rest. Let a child hold a long pointer in a similar direction, and let the children generally hold up their forefingers in that direction. Ask a child to hold a (new) lead pencil on the table in the same direction, and note that it will stand alone in that position, but not if set slanting. Explain that the direction taken up by a weighted string hanging freely at rest is called *vertical*. The term 'perpendicular,' often used in the sense of vertical, is very misleading, since a line in any position may be perpendicular to some other line.] Let them give another term often used in this connection—e.g. applied to the pencil standing alone on the table—*upright*; ask a child to stand upright, and

point out that it means he is to bring his body straight over his feet, and not to lean forwards or backwards or to one side.

Then direct some child to put the swing blackboard (or to hold a slate) vertical; and show how to test the accuracy of its position by means of the weighted string held near it. The string used in this manner is called a 'plumb line.' Let the children point out bodies in the room that are vertical—e.g. the walls, pillars, doors, &c.—and let them test some of those bodies with the plumb line. Also ask them to explain why such bodies are placed vertically; and illustrate the necessity for having a wall vertical by piling up a number of books one on another, first in that position, and then with each book slightly projecting over the one underneath.

Call the attention of the children to the direction taken by the surface of water at rest in a tumbler (or, better still, in a flat-sided bottle); ask one child to hold a pointer and another a slate in a similar direction. Draw on the blackboard a horizontal line crossing the previously drawn vertical line, and point out the four angles, and that all are equal. Say that all lines in that direction are called *horizontal* lines, and let the children point out horizontal lines and surfaces in the room. Refer to the common use of the word 'level' instead of horizontal, and let them state what bodies are characterised by their level surfaces—viz. liquids.

Hold a slate horizontally, and let a child lay a hard ball or marble on it: then incline the slate, and let the children describe the result, and explain why it rolled in the one particular direction. Lay the ball on the table, and let them explain why it does not roll—viz. because the surface is horizontal, and no part of it is lower than the rest. Then incline the table in a par-

ticular direction, letting the children first state the result they expect to see.

Make a drawing on the board of an inclined line, and give the name *inclined* or *slanting*. Exercise the children in holding a pointer or slate in vertical, horizontal, or inclined directions as requested.

Show that some rough, flat things will lie on an inclined surface—e.g. a book will lie on an inclined slate, but slides if the surface is much inclined. Let them state how they would describe the sloping surface of a hill; and point out that stones may lie on such a surface, or persons may stand and walk on it if not too steep. Then ask them whether things will rest by themselves on a vertical surface; and point out how maps, pictures, &c., have to be supported by nails, wall-paper by paste, &c.

Help them, in conclusion, to express as the general result of their observations that nothing will rest alone on a vertical surface; that solid bodies, even though very smooth and round, will rest on a horizontal surface; while on inclined surfaces rough flat bodies may rest if the inclination is not too great.

LESSON XXXII.

A BRICK.

OBJECTS REQUIRED—*An ordinary red brick; rule; piece of board (or old unframed slate); several thick books.*

ANALYSIS OF LESSON.

) object– its uses; colour.

Characters in which bricks generally agree.

Brick is a solid, not readily melted; proofs.

Material for bricks – shaping: baking.

Number of faces and angles (corners); advantage of flat faces.

Different sizes of faces, most steady position.

Ex.—*Set brick on various faces and note difference.*
Children set brick in best and worst position.
Push brick over from various positions.
Measure different sets of faces and draw plans on board.
Draw perspective view of brick; note number of faces visible.
Compare faces of bricks in wall, and measure.

Vertical and horizontal faces; advantage of horizontal position.

Ex.—*Describe position of various faces.*
Children set brick in position required.
Incline brick, and build several books on it.
Point out horizontal lines in wall.

Rough surfaces of brick – advantage.

Ex. *Rub finger on brick, compare with table, &c.*
Push brick along board or old slate; note noise and scratches.
Incline board till brick just slides down.

NOTES.

Subject of Lesson.—The examination of a common brick, with special reference to its form, will afford an opportunity of revising several matters observed in previous lessons. The difference in the size of its various faces, their relative positions, and the advantage of their being flat are subjects of easy observation and reflection.

Ask the children to name the object and describe its uses. Let them describe its colour, state whether all bricks are alike in that respect, and give any particulars in which bricks generally are alike—e.g. size and shape.

Like the ice and wax examined in previous lessons the brick can stand by itself on the table; what then should it be called? But the ice and wax could readily be melted; what name was then given to the substances? Let them state whether a brick could readily be melted, and give some reason for their statement—e.g. the use of bricks in fireplaces.

Perhaps some of the children can state how bricks come to be nearly all of the same size and shape—viz. that they are made so; they might also be asked to state what bricks are made of, what has been done to the clay to make it so hard and firm, and why the clay is made to its proper shape and size before being baked.

Next direct attention to the shape of the brick, the number of its faces and angles (corners). Let them explain why the brick stands so steadily on the table, and is not easily shaken or moved—viz. on account of its broad flat faces. For the same reason one brick (or a book) may be made to stand steadily on another.

Set the brick on several different faces in succession,

and ask the children whether it stands more securely on some faces than on others. Let some child place the brick in its most steady position, and another child place it in its least steady position ; then show how much more readily it may be pushed over in the latter case (letting it fall on to a folded duster). Let the children explain the cause of this difference—viz. the difference in size of the various faces—and lead them to say how many different sizes there are. Measure one face of each size, and make a plan of each on the board. Also draw a perspective representation of the brick on the board, pointing out that not more than three faces can be seen at once.

Then call attention to the bricks in the wall, and by measurement show that they are equal in size to the one on the table. Let the children explain the meaning of the small bricks seen here and there in the wall—viz. the ends of bricks set across the others—and let a child measure one such face, and compare it with the end of the specimen brick. (A word or two might be said about the manner in which the bricks are fastened together in the wall by mortar.)

Reminding the children of the terms 'vertical' and 'horizontal' used in the last lesson, let them state the direction of the various faces of the brick as it lies on the table ; and let children place the brick as required—e.g. with its largest faces vertical, with its smallest faces horizontal, &c. Raise the brick at one end, and let them describe certain faces as inclined or slanting. Ask them to state and explain in which direction the brick should be laid if others were to be built on it. Illustrate this by building several books on the inclined brick. Point out the horizontal lines in the wall.

Rub the finger on the table and then on the brick ; let a child do the same, and state the difference observed—

the brick is rough. Push the brick along a piece of board or an old slate, and call attention to the noise and the scratches. Lead the children to state what these facts also show. Then point out that this roughness is an advantage, in that a brick does not easily move when pushed, so that it stands all the more steadily and does not readily slip or slide. Illustrate this latter point by inclining the slate or board till the brick just begins to slide down it, noting that it does not slide easily and smoothly.

LESSON XXXIII.

A CYLINDER.

OBJECTS REQUIRED.—*Brick; board (or old slate); smooth cylinder with flat ends (drawing model, jam-pot, or round bottle); three cotton reels; two lead pencils; round and flat rulers; book.*

ANALYSIS OF LESSON.

Questions on brick—faces, steadiest position, &c.
Sliding of brick—noise and scratches.
Ex.—*Brick sliding on inclined board or slate.*
Push brick on board lying horizontally.
Brick may be rolled over.
Ex.—*Roll brick over from face to face.*
Child move book similarly.
Cylinder with flat and curved faces; *sliding* and *rolling*.
Ex.—*Set cylinder on end; push on table, and slide on inclined board.*
Lay on side and push it; note rolling.
Compare rolling of cylinder and brick—cause of difference.
Ex.—*Slide cylinder on rounded face.*
Roll cylinder over endwise.
Other bodies with rounded and flattened surfaces—balls, cups, &c.; advantages.
Bodies stand best on flat faces.
Ex.—*Try to set reel on its side on side of cylinder or other reel.*
Child build up three reels on end.
Bodies roll best on rounded faces—rollers.
Ex.—*Compare lead pencil to cylinder—roll, set up, &c.*
Place two lead pencils under brick, and roll.
Bodies with smooth surfaces move most easily—marbles, &c.
Ex.—*Slide lead pencil on table—note little noise.*
Advantages of round and flat rulers.

NOTES.

Subject of Lesson.—The difference of form between the rounded surface of a cylinder and the flat faces of a brick has an important bearing on the manner in which, and the ease with which, those bodies move, and on the stability of the bodies as supports for others. The sliding movement of the one is contrasted with the rolling motion of the other.

Commence with some questions on the subject of the last lesson—the number of faces of the brick, the variation in the size of the faces, the advantage of the faces being flat, and the steadiest position in which the brick can be laid.

Lay the brick on a board (or old slate), and incline the latter till the brick slides; let the children describe the movement as *sliding*, explain the cause of the noise and scratches, and state any advantage of the roughness of the surface. Show the same effects produced when the brick is pushed along a horizontal surface.

Another way of moving the brick apart from actually carrying it—may be illustrated by rolling (turning) it over from face to face, pointing out each time how it has to be raised on one edge and then dropped down on to the next face. Ask a child to move a book on the table in a similar manner.

Then take a cylindrical body with flat ends—such as a cylinder used in model drawing, a piece of curtain roller, or even a smooth jam-pot—set it on the table on one of its flat faces, and gently push it; ask the children to describe the manner in which it moves. Place it next on the same face on an inclined board, and let it slide down; lead them to compare the motion with that of the brick under the same circumstances.

Lay the cylinder then on its side and push it, asking the children again to describe the motion. Contrast it with the sliding in the previous case, and lead them to compare it with the rolling over and over of the brick; asking them, however, to describe the difference they observe in the two cases and to explain the cause of the difference. Point out that while the brick has four flat faces forming its sides the cylinder has only one face; and lead the children to describe the surface as rounded or curved, and to observe the absence of sharp edges, such as those of the brick. Show them again the cylinder sliding on its flat ends and rolling on its side; and ask some children to *slide* the cylinder along on its side (by holding it to prevent it from rolling) and to *roll* or turn it over on its ends. Give the name *cylinder.*

Ask them to name some other bodies with rounded surfaces (e.g. balls, marbles), and others again with flat surfaces (e.g. boxes, books), and describe the advantage of each kind. Ask them to explain why jam-pots, cups, bottles, &c., have flattened ends.

Then show how difficult it is to make one cylinder rest steadily on another on their curved surfaces by trying to lay a reel of cotton on the cylinder, or one reel on another. Give a child two or three reels, and ask him to set them one on another in some better way.

Show them a new lead pencil; lead them to compare it with the cylinder, and let some child lay it ready to roll, and another set it to stand. Ask them to state the direction of the various faces in the two positions – i.e. whether vertical or horizontal. Place the pencil (or better, two similar pencils) lying on its rounded side under the brick or a book, and show how much easier it is to move the body along in that manner. Let the children state

what round objects are generally placed on or under heavy carts, &c., to enable them to move easily.

Hold the pencil and slide it along the table or board; point out that it does not make so much noise nor scratch so much as the brick did, and let the children give the reason for this viz. that the surface of the pencil is much smoother. Let them also state the simplest way of ascertaining whether a body is smooth or rough. Let a child compare by touch the surface of the pencil and of the brick. Let them explain why marbles roll so easily—viz. because round and smooth.

Briefly point out that sometimes flat and sometimes round rulers are used for ruling lines, and lead the children to state and explain the special advantage of each kind.

LESSON XXXIV

A WHEEL.

OBJECTS REQUIRED—*Lead pencil; book; penny (or larger circular metal disc); knitting-needle; cotton reel (large size); paper or cardboard disc (e.g. the lid of round box); drawing pin; rule; piece of string; small model of cart or toy with wheels.*

ANALYSIS OF LESSON.

Questions on movement of brick and cylinder—'sliding' and 'rolling.'

Ex. *Illustrate by book and lead pencil.*

Advantages of rolling; rollers.

Ex. *Move book on table with pencil as roller.*

Penny (or disc) may roll or slide; different surfaces.

Ex. *Ask children to roll and to slide penny.*

Means of guiding moving body—wheels.

Ex.—*Let child try to roll reel or penny along line.*
Roll reel with knitting-needle through hole.
Trace outline of penny and end of reel on board; mark position of axle.
Show model cart with wheels; note axles and circular outlines.

Position of guide (axle) in centre of circle; reason.

Ex.—*Turn circular disc of paper or card round pin in centre; then round pin not in centre.*

Wheels not always solid pieces.

Ex.—*Draw outline of wheel, showing rim, centre-piece, and spokes.*

Size of wheel given by diameter or circumference.

Ex.—*Let children measure diameter of penny, reel, &c.*
Measure circumference with string, and then length of string by the rule.

Applications of wheels—casters on tables, &c.: pulleys.

Use of grease.

NOTES.

Subject of Lesson.—The subject of this lesson is for the most part a continuation and further development of that of the last lesson—viz. the great advantage of rolling over sliding motion when freedom of movement is desired. The wheel is the commonest form in which this principle is practically applied, and several points connected with the shape and use of wheels are brought forward as subjects of observation.

Briefly revise the manner in which a brick (or book) and a cylinder (lead pencil) may be moved along the table or floor, the difference in the two cases, and the reason for this difference. Lead the children to make use of the terms 'sliding' and 'rolling,' and let them give other examples of such movements—e.g. a child may roll down a hill, slide on ice, &c.

Let them state which of the two kinds of movement would be easier along a rough surface—e.g. in moving a heavy stone or box along a rough road. Point out that our floors, roads, &c., are usually rough, and let the children give examples of smooth surfaces—e.g. polished wood, glass, ice, &c. Remind them of the advantage of using rollers in moving heavy bodies (cupboards, &c.) along the floor; and illustrate this, as in the last lesson, by means of a book resting on a pencil.

Take a penny, or, better still, a larger circular metal disc, and ask one child to slide it along the table and another to roll it. Point out that they use two different parts (surfaces) of the penny in the two cases; and lead them to describe the difference in the form of the two surfaces employed—one being flat and the other curved.

Then roll an ordinary cotton reel on the table. Let

a child try to set the reel rolling along a marked line; and, after noting the difficulty of doing this, show how the reel may be guided by holding a knitting-needle through the hole in the centre of the reel. Let some child make a tracing on the board of the penny as it stands when rolling; then make a similar tracing of the end of the reel and mark the position of the central opening.

Lead the children to compare the reel moving in the manner described with the wheels of a cart, and let them state the points of resemblance. Show them some toy or model cart with wheels attached; let them describe the manner in which the body would move in the absence of wheels, and then state the advantage of the wheels. Let them try to explain why the pin about which the wheel turns is placed in the centre; and show them by means of a circular piece of paper (or cardboard) how evenly it moves about a (drawing) pin placed at the centre, and how irregularly it moves about a pin placed at any other point. Let them describe the result of the wheels of a cart not having their axles placed exactly in the centre.

Point out that as a general rule the wheels of vehicles are not made of one solid piece, like the reel or the paper disc, but built up of several pieces with bars to the central portion. Make a simple drawing on the board to illustrate this point.

Let them explain how they would describe the size of a wheel; and let some child ascertain the size of the penny or a wheel by measuring both the diameter (with a rule) and the circumference (with a piece of string afterwards applied to the rule).

Ask them to give examples of the use of wheels in other cases than carts—e.g. tables, pianos, blackboards, &c. —and let them describe the advantage of such arrange-

ment. Also refer to the somewhat different use of wheels as pulleys for window cords, &c., to pass over; and help them to explain the use in such cases as making it easier for the cord to move than it would be if the cord had to slide over something fixed.

The use of oil or other substance might be mentioned, and the children asked to describe its use, the particular place where it is used, and the reason for using it in that special place.

LESSON XXXV.

A MAGNET.

OBJECTS REQUIRED—*Ball; cylinder (or lead pencil); horse-shoe magnet (at least four inches long) with 'keeper'; nail (about two inches long); knitting-needle; pen-nib; thread to suspend nail and needle; table knife; needle; brass pin; shilling; halfpenny; small key; small pieces of string, paper and wood; several small iron nails on plate or paper.*

ANALYSIS OF LESSON.

Some cause required to produce motion.

Ex. *Move cylinder and ball by pushing, blowing, raising table, &c.*

Difficulty of moving some bodies—brick, cart, &c.

Power or strength required—horse, &c.

What moves dust—leaves—kettle-lid?

Children recognise magnet and describe manner of use.

Ex.—*Child repeat any experiment with magnet.*

Magnet has power to move certain bodies.

Ex. *Attract suspended nail; repeat several times.*
Attract suspended knitting-needle; lift pen-nib and nail.

Magnet can support body from falling.

Pull of magnet can be felt.

Ex.—*Let child pull nail and 'keeper' from magnet; state which power stronger.*

Magnet acts only on iron.

Ex.—*Try various substances; name those affected.*
Try magnet with other iron bodies suggested.

Power of magnet principally at free ends.

Ex.—*Place 'keeper' on various parts, and pull away.*
Dip magnet among small nails; note nails clinging together.

Enumerate bodies having power.

NOTES.

Subject of Lesson.—The motion of bodies having been considered at some length in the preceding lessons, it is now desired to direct attention to the fact that some cause must act to produce motion, and that this cause may be exerted in various ways and by various agents. The action of a magnet in moving and supporting pieces of iron and steel is readily observed, as is also the fact that the force in this case appears to act only on one particular substance.

Point to the ball, or to the cylinder lying on its curved face on the table, and ask the children to state again the advantage of those curved surfaces; and also the advantage, in this same connection, of the smooth surface of the table. Then point out that, however smooth the table and the ball or cylinder, the latter lies still and does not move until something is done to set it in motion. Let them mention several ways in which the body might be made to move e.g. by pushing it, rolling something against it, blowing against it, or raising the table at one end. In each case something must be done to the body before it will move.

Then refer to a brick lying on the table, and let the children describe how it might be made to move; pointing out that it also lies still until something makes it move. Let them also state whether it would be more difficult to move the brick or the cylinder. The difficulty of moving a very large stone or a cart full of bricks would be much greater, perhaps too great for an ordinary person; and the children might be asked to describe how such bodies are usually moved—e.g. by horses, engines, &c. Let them explain why if a person could not move such bodies a horse could—viz. that the horse is stronger, or has greater

strength or *power*. Lead them then to the conclusion that strength or power (or force) is required to move all these bodies, and the more difficult it is to move the body the greater the power required. Ask them to state what the power is which moves the dust in the street, and the leaves and branches of the trees; and what it is that exerts the power which sometimes lifts up the kettle-lid.

Then show them the magnet—an ordinary horseshoe magnet or 'loadstone.' If any child is able to recognise it, let him describe some experiment he has seen performed with the magnet; and let him, if he can, perform some simple experiment with it.

Hold the magnet near an iron nail (about two inches long) suspended by a long piece of thread held in the hand (or, better still, hung steadily from some fixed support, as from a projecting book on the top of a pile of books). Let the children state what they observe to occur; repeat the experiment several times, and show that holding the finger near the nail does not produce the same effect. Lead them to state that the magnet has *power* to move the nail.

Similarly suspend a knitting-needle, and move it by holding the magnet near one end; hold the magnet over a pen-nib laid on the table, so near that the nib is drawn up and clings to the magnet: also pick up the nail in the same way. Ask the children what it is that keeps the suspended knitting-needle from falling, what in the first instance kept the nail from falling, and what now (i.e. when held by the magnet) keeps it from falling—viz. the power of the magnet.

Let a child pull the nail from the magnet, and also pull away the small iron bar (or 'keeper') sold with the magnet, and kept joining the ends or 'poles' of the magnet

when not in use. Ask the child to note whether he feels the magnet pulling the bodies; let him put the 'keeper' to the magnet and again feel the pull. Then lead the children to explain that, although both the child and the magnet pull the iron, the former pulls the harder, or is the stronger. Let them give their reason for the statement.

Try with the magnet to pick up small pieces of wood, paper, a needle, a pin (made of brass), a shilling, a half-penny, a small key, a piece of string, &c. Write down on the board (as the children enumerate them) the names of all the bodies on which the magnet has power to act. Say that there must be some reason why the magnet acts only on these bodies; and let the children suggest in what respect they all agree (and differ from those found to be unacted on). Help them ultimately to observe that all the bodies acted on are made of iron (or steel).

Let the children name any other bodies made of iron, and, where possible, test them with the magnet, noting whether it clings to them—e.g. the scissors or a knife may be moved or partly raised if the magnet is held to one end; the magnet will perhaps cling to a poker or a knife, and hang from it. Point out that the magnet itself is made of steel.

Dip the ends of the magnet among a number of small iron nails (common 'tacks' or 'brads'), and hold it up, letting the children describe clearly what they observe. Let them see clearly not only how the nails are held to the ends of the magnet, but also how they cling to each other. Point out that the nails did not cling together before, and help the children to express the inference that the magnet has given the nails power to hold each other.

Show them, by putting the 'keeper' or a nail at dif-

LESSON XXXVI.

A PAIR OF SCALES.

OBJECTS REQUIRED—*Pair of scales (say, with brass pans and beam about nine inches long, in box): two similar books; penny; two halfpennies; one pound weight; sand (more than one pound), with scoop or spoon.*

ANALYSIS OF LESSON.

Name instrument—use.

Ex. *Children test two books: also penny and two halfpennies.*

Description of instrument—beam, pans, pivot.

Pressure of bodies in pans.

Ex.—*Hold up scales, put book in one pan—explain descent.*

Child press other pan down; explain.

Child press equal to book.

Position of beam with equal and unequal weights.

Ex.—*Put similar books in pans—note beam.*

Add small weight to one pan.

Names—'balance' and 'pair of scales.'

Swinging of beam—pendulum.

Ex.—*Put equal weights in pans and set beam swinging.*

Beat time with swings.

Observation made while swinging.

Ex.—*Repeat with somewhat unequal weights.*

Special bodies as 'weights'—weighing.

Ex.—*Weigh one pound of sand.*

Take out pound weight; divide sand equally in pans.

Does weight of pan itself count with substance?

Arrangements for weighing liquids—weight of containing vessel.

Various forms of scales.

NOTES.

Subject of Lesson.—The use of the common balance (or 'scales') for weighing is well known, and the general principle on which it acts is very simple—viz. that with substances of equal weight in the two pans the beam remains horizontal, or swings evenly. This general principle, and various other matters in connection with the practical use of the instrument, form the subject of the present lesson.

Let the children give the name of the instrument shown to them, and also state its use. Let one or more of them illustrate the manner in which it is used, and ascertain which of two books is the heavier, whether a penny is equal in weight to two halfpennies, &c.

Assist them to describe the instrument as consisting of two pans hanging from the ends of a bar (or beam) which can move easily on its support. Let them point out this support, and lead them to compare it with the pivot in the compasses and tongs.

Ask the children to state the use of the pans, why they are usually made hollow, of what substance the pans in the particular instrument under consideration are made, and why the balance when used must be held or supported so that both pans do not rest on the table.

Place a book on one pan while the scales are being held up, and let the children explain why the pan goes down. Let one child with his hand press the other pan down, and ask the others to say whether the book or the hand presses the more, and to give their reason. Ask the child to press with his hand just as hard as the book presses, and let the others explain how they know when that is being done.

Then place a book similar to the other one in the

second pan, and before holding up the instrument let the children describe fully what will be ascertained when the scales are held up. Hold them up, and let the children state the result of their observation. Direct their attention to the beam, and ask them to describe its actual position, and to state in what position it should stand (1) if both books were equal in weight, and (2) if one were heavier than the other. Also let them state the position in which the beam should stand when the pans are empty, and take out the books to test their statement.

Explain that when the beam stands horizontally the weights in the pans are said to *balance*, and hence the instrument is often called a balance. Let them also explain why it is usually called a *pair* of scales, and give other illustrations of the use of the word 'pair.'

Placing similar bodies (books, marbles, &c.) in each scale, make the beam swing: lead the children to compare it with the swinging pendulum, and let them count, or beat time with, the swings. Ask them whether they could tell while the pans and beam were swinging whether the bodies were about equal in weight, and to explain how they could do so. Illustrate this by putting slightly unequal weights in the pans, and let them observe the swinging of the beam.

Then show them a one pound weight, and explain that such bodies are carefully made and kept purposely for use in weighing. Place it in one pan, and put sand (or other substance) in the other pan till it is balanced; then let the children state how much sand the pan contains. Ask them whether the weight of the pan itself counts—i.e. whether the sand and the pan together weigh one pound, or the sand alone—and let them give reasons for their answer. Then take out the pound weight, and let a child take out part of the sand

from one pan and place it in the other until the two again balance; then let them describe how much sand there is in each pan.

Let them next describe how they would proceed to weigh out a pound of water (or treacle), and explain how they would arrange so that the weight of the vessel to contain the liquid should not be included.

If there is time, ask them to name various articles which they have seen weighed—sugar, bacon, flour, meat, coal, &c.—and let them describe, if they can, in what way the scales were different in shape from those shown, and, where possible, suggest some reason for the differ-

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